# finishing

APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, ...IZING, METAL SPRAYING and all METAL FINISHING PROCESSES

Vol. 4 No. 41 (new series) MAY, 1958



UNIVERSITY OF MICHIGAN

JUN 11 1958

ENGINEERING LIBRARY

...itish Titan Products

brighten products

especially

**INDUSTRIAL PAINT FINISHES AND VITREOUS ENAMELS**

*where the lasting gloss and brilliance of whites and tints can only be obtained with TITANIUM OXIDE*

BTP TITANIUM PIGMENTS

18-28

...RITISH TITAN PRODUCTS COMPANY LIMITED 10 Stratton Street London W.1

INSPECTING ZINTEC SHEETS

SUMMERS

. . . for ZINTEC

an electrolytically coated steel sheet

JOHN SUMMERS AND SONS LTD · HAWARDEN BRIDGE STEELWORKS · SHOTTON · CHESTER

# metal finishing Journal

May, 1958 AN INDUSTRIAL NEWSPAPERS PUBLICATION Vol. 4, No. 41 (New Series)

*Editor :* JOHN HOOPER *Assistant Editor :* E. H. LLOYD, A.I.M., A.C.T.(Birm.) *News Editor :* L. J. BACON
*Southern Area Manager :* E. COLLIS *Northern Area Manager :* G. P. ELLIOTT *Scottish Area Manager :* T. H. SMITH
*Western Area Manager :* E. J. SWEETING *Eastern Area Manager :* ERIC PERRIN
*Production Manager :* R. J. LOVELL *Circulation Manager :* E. T. GRIFFITHS *Publisher :* H. J. DWYER

*Official Organ of the*

**INSTITUTE OF VITREOUS ENAMELLERS**

*President :*
C. R. WHEELER, C.B.E.

*Chairman :*
J. H. GRAY

*Secretary :*
J. D. GARDOM
John Gardom & Co., Ripley, Derby
*Telephone :* Ripley 136

*Published on the 15th day of each month by*

**INDUSTRIAL NEWSPAPERS LIMITED**

Directors:—
Barrington Hooper, C.B.E., *Chairman and Joint Managing Director*
F. Barrington Hooper, *Joint Managing Director*
F. R. Lewis
John Hooper
D. Horn
E. G. Weston, *Secretary*

**JOHN ADAM HOUSE**
**17-19 JOHN ADAM STREET**
**ADELPHI, LONDON, W.C.2**
*Telephone :* TRAfalgar 6171 (P.B.X.)
*Telegrams :* Zacatecas, Rand, London

*Subscription Terms :*
Home and Overseas 24*s.* per annum prepayable
Single copies 2*s.* (2*s.* 4*d. post free*)

THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

## Contents

PAGE

**Full House** ... ... ... ... ... ... ... **153**

**Talking Points** ... ... ... ... ... ... **154**
*" Platelayer "*

**METAL FINISHING ANNUAL CONFERENCE** ... **155**
**Report and Pictures of the Annual Conference of the Institute of Metal Finishing held at Torquay on April 16-19**

**Finishing Post** ... ... ... ... ... ... **180**

**Oil and Colour Chemists Exhibition** (*concluded*) ... **181**

**Finishing News Review** ... ... ... ... ... **183**

**Plant, Processes and Equipment** ... ... ... **191**

Pyrene TRADE MARK

INDUSTRIAL

**P**roducts

**P**ay

**D**ividends

*Save money . . . Save man-hours . . . Save production worries*

**P**reperite

For the removal of rust from iron and steel, and corrosion products from non-ferrous metals.

**P**ultac

Strippable material for protection of the dry walls of paint spray booths.

**D**etac

Deglutinating material for the treatment of water in water-conditioned paint spray booths.

*For full details write to Dept. B. 5*

**THE PYRENE COMPANY LTD · METAL FINISHING DIVISION**

GREAT WEST ROAD · BRENTFORD · MIDDLESEX Tel: EALing 3444

# FULL HOUSE

*IT has now become apparent that there is no hotel at any of the accepted conference centres in this country which is capable of housing under a single roof all those desirous of attending the Spring Conference of the Insititue of Metal Finishing. This fact in itself bears sufficient witness to the steady growth in popularity of this annual function. If it is taken in conjunction with the quality of the technical papers read at the Conference and the standard of the technical discussion following their presentation, it adds up to a picture which would seem to illustrate a growing awareness of the need to move metal finishing from the realm of an empirical craft to the status of a skilled technology, well rooted in a proper scientific knowledge of its fundamentals.*

*This move is certainly not yet complete, indeed it can hardly be said to have more than just begun, but the fact that a movement of this nature is taking place and in the right direction, is of great significance, for such developments very often tend to be autocatalytic. That is to say, good technical contributions beget their kind.*

*Without in any way belittling the sterling achievements of the Electrodepositors Technical Society and the pioneering part it played in promoting the dissemination and discussion of technical information on plating processes, few would deny that the nature of much of its published material approximated more closely to what would be found in the pages of a manual of electroplating practice rather than in the proceedings of a technical organization. No doubt this was the normal evolutionary procedure and the Institute can now safely claim that it offers the proper platform for the publication and discussion of matters of fundamental science relating to the basic concepts of metal finishing. Full credit must be paid to the far sighted and devoted zeal with which the administrators of the Institute have brought this state of affairs to pass and who can now congratulate themselves on coming within sight of their goal.*

*However, the greater the influence the greater the responsibility and the time may well have come for the Institute to make a careful re-appraisal of its new position. There is no doubt that the annual conferences over the past decade have been very pleasant social occasions and have borne much good technical fruit. A considerable contribution to the enjoyment of all concerned has been the selection of a spa or a seaside resort as the venue. Although the attractions that such places have to offer must in some measure have influenced their selection, the choice is also dictated to a considerable extent by the fact that only in such places are found hotels adequately equipped to accommodate the delegates and provide the necessary facilities.*

*As we stated in our opening paragraph however, even the large seaside hotels are now incapable of housing the full conference, and it is inevitable if the present increase in numbers continues that delegates in future will be more widely spread as far as accommodation is concerned. Once the need to seek accommodation on a massive scale is abandoned, the number of potential venues for the conference is immediately increased greatly. While there is no gainsaying the fact that the attractiveness of a seaside resort plays a large part in fostering attendance at the conference, it is also undeniable that the need to travel long distances must militate against the attendance of many who would have something of value to contribute to the discussions, but who are unable to devote more than a limited amount of time to such activities.*

# Talking Points

*by* "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

## ORDEAL BY CONFERENCE

NOW that the Annual Conference of the Institute of Metal Finishing is over it seems opportune to comment once again on the Conference Room conditions to which those attending the meetings were subjected. For, while our technical associations can organize papers, invitations, dinners and even bathrooms, they seem quite unable to cope with the simple mechanisms of a lecture hall.

The weather was kind, and the room was spacious with plenty of windows. But all these had to be closed and the curtains drawn all the time in case someone wanted to show a slide. Most of those actually shown could have been safely omitted in any case, as diagrams had been pre-printed and were in any case often so small as to be undecipherable. The result was that speakers could not be seen in the gloom and could barely decipher their manuscripts, while the audience stifled or dozed. Writing on the blackboard could not been seen until someone precariously balanced a standard lamp against it, and in this age of electronics, the microphones, as invariably happens, failed to work most of the time, so that speakers were often both invisible and inaudible.

These conditions have now become traditional and will no doubt be repeated next year.

## WHAT SHALL WE CALL IT

POLISHING metals mechanically by means of a buff, and electrolytic polishing whereby the metal is removed by making it anodic in a suitable electrolyte have been regarded as distinctly different, and perhaps competitive processes. It has been left to the General Motors Corporation to develop a way of combining these two very different ways of metal removal, which at first sight seem to be quite incompatible. In a recent patent they describe a method of grinding and polishing in which a wheel of aluminium oxide bonded with a metal conductor is made the cathode and the work the anode. The electrolyte consists of a film of a solution of sodium carbonate and sodium silicate running over the wheel. The current is pulsed d.c. at 10-30 volts, the current density being 300-360 amps per sq. ft.

This is certainly an ingenious if complicated system, and would have to have very decided advantages if it were to be adopted at all widely. The next step will no doubt be to run a polishing wheel in the plating bath !

The only problem that remains is to find a name for this combination process.

## B.S.I. SLIPS UP

THE British Standards Institution, which no-one would deny is a body of high repute, runs a Consumer Advisory Council which periodically issues a Shoppers' Guide to its members telling them of the relative merits of various commercial products. The latest issue, No. 4, deals with, amongst other things, electric fires : it includes some comments on reflectors, and proceeds to make the forthcoming statement :

" Polished aluminium is more durable than anodized ".

Considering that anodizing is a process which has developed and is applied at considerable expense to aluminium with the primary objective of improving its durability, this sentence succeeds in packing more misinformation into fewer words than anything I have read for a very long time.

One gets used to seeing a good deal of nonsense in print about metal finishing, but to find it in a B.S.I. publication comes as something of a shock.

## TRANSATLANTIC MODESTY

IN these days when every maker of a machine seeks a superlative name for it, it is interesting to find an example of a becoming modesty in the United States, of all places, where a new thermonuclear fusion reactor at California University, Los Alamos, has been called a " Perhapsatron ".

It will be a change to see advertisments for say, the " Sometimesbright " Nickel Plating Solution instead of all the " Ultras " and " Supers " we see so much of.

In this respect industry appears to be competing with the film world, and I am reminded of the story of the two Hollywood tycoons who met in a hotel lobby. " How's business ? " said the first " Terrific " came the reply. " Never mind ", said his friend, commiseratingly, " I expect it will pick up ".

## VERBAL CURIOSITIES

A well known firm of razor manufacturers is now advertising its products as " tempered by frozen heat ". Every trade has its jargon, and no doubt those in close touch with modern heat treatment techniques may know what this means, although to me it seems nonsense. No doubt, I suppose, to heat treatment specialists the term " electroless plating " would be unintelligible.

We now await with impatience the advent of coatless painting !

# THE METAL FINISHING CONFERENCE

## A Report of the Annual Conference of the INSTITUTE OF METAL FINISHING held in Torquay on April 16-19

THE tenth in the series of major residential conferences organized since the end of the War by the Institute of Metal Finishing was held at the Palace Hotel, Torquay on April 16—19.

The official proceedings of the Conference were launched on the first morning by a formal address of welcome from the Mayor of Torquay, Councillor A. L. Goodrich, who was received by the President of the Institute, Dr. T. P. Hoar and the Immediate Past President, Mr. R. A. F. Hammond. On the same evening the delegates and their ladies were entertained by the Mayor and Corporation at a Civic Reception and Dance at the Palace Hotel.

The culminating social event of the Conference was the Conference Dinner and Dance held at the Palace Hotel on the final evening. This filled the available accommodation to capacity and proved a most enjoyable function. The principal guest was Sir Owen Wansbrough-Jones, Chief Scientist to the Ministry of Supply, who replied on behalf of the guests and kindred societies to the toast proposed by the President.

During the Conference the opportunity was provided by kind invitation of the directors of the companies concerned, for members to visit the Marine Research Station of I.C.I. Ltd. Paints Division, and the Exposure Station of Pinchin Johnson and Associates Ltd., at Brixham. The Marine Research Station was established at Brixham by the Paints Division of I.C.I. Ltd. in 1947 primarily to carry out research on the problems associated with marine paints, and this work is still the major interest of the Station. Research is carried out on all types of marine paints including underwater paint systems designed to protect the steel hulls of ships from corrosion and fouling by marine organisms such as barnacles. Testing of these paints is carried out in flowing sea water

in the laboratory and on rafts moored in the harbour, which are also used for testing the performance of paints used on the topside and superstructure of ships. New and specialised paints for the holds of tankers, cargo spaces etc. are also designed and tested at Brixham.

The party who visited the Pinchin Johnson Exposure Station saw approximately 5,000 panels on exposure, testing the durability of automobile finishes, house paints, aircraft finishes etc. The site is also used by the British Iron and Steel Research Association as part of their exposure programme. A resident inspector keeps records of the weather conditions throughout the year and submits reports on the panels at regular intervals.

The usual competition for the John Preston Golf Trophy was held during the Conference at the Torquay Golf Club. On this occasion Mr. R. G. (Jim) Hughes repeated his last year's success with Mr. J. N. T. Adcock coming second, and Mr. H. Horrocks third.

The weather throughout the Conference was excellent and the facilities provided by the Palace Hotel, where the bulk of the delegates were accommodated, were clearly enjoyed by all. The attendance at the technical sessions was very well maintained at all times and although our contributor "Platelayer" has seen fit to include among his "Talking Points" elsewhere in this issue some criticisms of the conditions obtaining during the technical sessions, this seemed to have little effect on the keenness with which the various papers were discussed.

In the pages which follow we present short abstracts of the technical papers, together with a preliminary report of the discussion which followed their presentation. The full text of the papers and the authoritative version of the discussion will be published later by the Institute of Metal Finishing.

*Abstract No.* 1

## The Effect of Interposed Layers of a Second Metal on the Weather Resistance of Electrodeposited Nickel Coatings.

*by B. B. Knapp.**

THE progress of research on undercoatings for chromium has been hampered by the lack of an adequate theory to account for the deterioration of a decorative nickel-chromium coating, and also by the lack of a reliable accelerated test to appraise coating performance. Two theories have been advanced to account for the mechanism of atmospheric deterioration—the porosity theory and the corrosion pitting theory.

A development of the porosity theory which related to buffed dull nickel was that corrosion followed the boundaries of the columnar grains, which are normal to the surface. Attempts to establish this by interposing a copper layer between two nickel layers to interrupt the grain boundaries showed a poorer performance than a single nickel layer of comparable thickness. This can be attributed to the detrimental influence of copper corrosion products because of which the interposition of a copper layer may not give a representative picture of the effect of interrupting the columnar grain structure.

The work described in this paper was undertaken to study the effect of interposing layers of a second metal between two layers of nickel, metals selected including copper, iron, chromium, lead, tin, zinc, cobalt, silver and palladium. Dull nickel deposits were used, buffed, and plated with decorative chromium. Samples were exposed at various weathering sites.

Results in a majority of cases showed superior performance over single nickel layers. Two factors are believed to be responsible for this improved behaviour. First, the interruption of the columnar grain structure tends to obstruct the development of corrosion pits. Second, certain combinations of metals in composite coatings appear to have a favourable pattern and direction of galvanic current.

In a second programme of work, four of the most promising metals (chromium, cobalt, tin and silver) were plated in varying thicknesses, and also 3 layer nickel coatings (to interrupt structure). The results of this programme indicate that the galvanic relationship of the metals is probably the more important factor, as the interruption of the structure with an intermediate (non-columnar) nickel layer did not improve performance.

In general it is concluded that the interposition of a second metal layer can improve substantially the performance of a decorative nickel-chromium finish, and further work is contemplated.

*Abstract No.* 2

## The Nickel and Chromium Plating of Steel Iron Covers.

*by G. Arnold**

This paper describes the new sequence of operations adopted to produce a bright nickel/chromium finish on pressed steel domestic iron covers and makes a fairly detailed survey of the economies of the process as compared with the process as originally carried out. The original process involved steel polishing, cleaning, plating in Watts dull nickel solution, nickel polishing

*Research Laboratory, International Nickel Co. Inc., Bayonne, New Jersey, U.S.A.

*Works Chemist, Hoover Ltd., Greenford, Middlesex

and chromium plating. The new system is steel polishing, cleaning, Rochelle copper, copper polishing, bright nickel plating and chromium plating.

The cost of materials in the new process is only half that of the old, and a saving of 30 per cent in labour requirements for the two polishing operations, and of 40 per cent for plating have been made possible.

It is concluded that on the production figures obtaining, sufficient saving can easily be made in 12 months to cover the capital outlay on the copper plating equipment. Under corrosion resistance testing it was found that on the unpolished interior surfaces the copper/nickel/chromium finish was to be preferred but on the polished surfaces no difference could be found between the performance of the two types of finish.

## Discussion

MR. H. C. CASTELL (Development Officer, The Mond Nickel Co., Ltd.) referring to Mr. Arnold's paper said that he wondered whether the introduction of a copper plating sequence and polishing at the copper stage had indeed effected the maximum reduction in the processing costs. The organic-containing nickel-plating solutions in use today confer such a high degree of levelling in either semi-bright or fully bright deposits that some reduction of the initial polishing costs was certainly possible. Although Mr. Arnold was using a bright nickel solution he did not state whether it had levelling properties. If that was so, then surely he was losing some of the advantages of modern nickel-plating solutions by introducing copper and polishing this to a high lustre. If, on the other hand, a copper layer was necessary to obtain a high lustre in preparation for the bright nickel, was it really necessary to polish the basis steel to a '180 grease' finish ?

As to the relative performances of the two finishes, it was inferred in the conclusions of the paper that 0.00035 in. of copper + 0.00025 in. of nickel was superior to 0.00045 in. of nickel, these being the thickness figures on the inside surfaces of the iron covers, but it was not really fair to draw such a comparison on even 50 parts when tested at different times over a period of six months. The tests, when applied to the outside surfaces of the covers, were clearly too insensitive to determine any difference, since neither all-nickel deposits nor copper/nickel composite deposits showed any corrosion in either the acetic acid/salt-spray or the humidity test.

It had been however, fairly firmly established nowadays, with nickel and chromium plated articles in corrosive environments, that one of the most important factors in determining the degree of corrosion protection was the thickness of the nickel deposit, whether or not a copper undercoat was used. This had been largely established by a very long and comprehensive series of tests carried out by the A.S.T.M. in a large number of atmospheric corrosion conditions. In this particular case, therefore, he would like to see a more rigorous and comprehensive test, applied to both types of finish at the same time, when he was sure that Mr. Arnold would find that 0.0007 in. copper + 0.0005 in. nickel considerably inferior to 0.002 in. nickel by itself.

Mr. Arnold had stated that he found that when a proportion of the nickel deposit was replaced by copper the material costs were cut by about half. Was this a justifiable statement when in fact the total deposit thickness has been cut by 40 per cent from 0.002 in. to 0.0012 in. ? If the costs were compared, when the deposit thicknesses in both methods were the same, the reduction in material costs was 35 per cent.

In other words, if material cost reduction was important he could have achieved quite a substantial cut, of the order of 20 per cent by reducing the nickel thickness to 0.0012 in. which would have produced a finish certainly as good as if not better than the present nickel/copper composite deposit.

Mr. Arnold had also implied that the material costs were a very significant part of the total processing costs. It was a pity that these total costs had not been shown in greater detail. From what Mr. Arnold has said it appeared that the plating costs were about one-third of the total costs in both processes, but that did not show the relationship between the cost of the metal deposited, the material costs, and the total processing costs. When labour, material and overheads were all considered, the material cost in most metal finishing processes represented quite a small proportion of the total.

Referring to the paper by Dr. Knapp, Mr. Castell said that many people would be wondering how the technique of interposing a chromium layer between two nickel layers could be achieved in practice, bearing in mind the relative inflexibility of automatic plants, of introducing chromium plating plating tanks in the middle of nickel plating sequences, of unracking and re-racking the work and of the extra space required by the swills, chromium plating and the activating nickel strike. Dr. Knapp had suggested a possible answer to that problem when he said that a chromium layer nearer the basis metal was, perhaps, more effective than one with equal thickness of nickel on both sides. Taking that a stage further, would it not be possible to consider the first nickel layer, the chromium plating and the nickel activating strike as a separate pretreatment and to follow that with the normal nickel/chromium plating procedure ?

With regard to the introduction of a chromium plating process in the middle of the nickel plating sequences, he wondered whether Dr. Knapp would comment on the suggestion that tin-nickel might be just as effective as a chromium interleaving layer. Tin-nickel was, he thought, slightly cathodic towards nickel and in addition it was plated from a more manageable and less noxious solution. Moreover, it was possible to plate tin-nickel alloy without cracks or discontinuities which in chromium allow further penetration to the basis metal. Also tin-nickel has high covering and throwing power and, indeed, might help to improve the coverage of the second nickel layer over the surface of the article. Had the author any experience of tin-nickel as an interleaving deposit ?

### Application to Zinc-base Die Castings

Mr. Castell also asked about the possibilities of using this technique on zinc-base alloy die castings. On that alloy it was standard practice to apply a somewhat thinner coating of nickel than on steel and while an improvement in the quality of plated zinc-base alloy castings required a thick nickel deposit, a lack of production capacity often restricted the actual application of thicker deposits. If, therefore, it were possible to obtain twice the corrosion protection by using an interleaved deposit while maintaining the nickel thickness at the original figure, it would lead to a considerable improvement in service life.

Another suggestion was the placing of the chromium layer directly on to the basis metal. According to Dr. Knapp's explanation of the mechanism of the improvement in corrosion protection, there should still be a substantial improvement if the first nickel layer were omitted since when corrosion pits had penetrated to the chromium layer it would then provide a cathodic barrier against further attack on the anodic basis metal. The chromium, of course, might well be discontinuous and would therefore allow further penetration of the corrosion pit to the basis metal, but with the new developments in continuous crack-free chromium it might be feasible after all.

Mr. Castell concluded by asking Dr. Knapp whether there had been any practical demonstration of his composite coating technique and whether any plater in the United States had used it ? If so, could he describe the plating sequence adopted and say what alterations in the existing process had had to be made and what was the behaviour in service of articles plated in this way ?

Mr. J. M. Sprague (Consultant Electrochemist) said that Dr. Knapp had justified quite reasonably the use of certain unlikely coatings in order to find out in an experimental way some general points about the mechanism of coating, but there were other aspects of his work which he found so remote from what might be commercial practice that he wanted more information about them.

Dr. Knapp had mentioned that he had deposited to a total thickness of .001 in. to afford a ready comparison and he wondered why he had chosen that figure, especially when it was realised that a lot of the corrosion resistance of those coatings, composite or otherwise, depends upon the influence of porosity. It meant that the thickness of some of the individual layers used was extremely small.

Dr. Knapp had specified certain compositions but he would welcome more information about the composition of the solutions used. In particular it could be very important to know what chromium solution he had used ?

Mr. R. M. Angles (Electroplating Development Department, Tin Research Institute) asked Dr. Knapp from what type of tin solution the under coats were plated. He also requested details of the methods of flowing and polishing of tin cobalt.

### Determination of Thickness

Dr. S. Wernick (Consultant) said that he was particularly interested in the fact that Dr. Knapp was able to obtain such extraordinarily thin deposits with such accuracy, and it would be valuable if he were to describe a little more in detail how he did it. It was sometimes possible to obtain accuracy within 1.25 per cent using the Magne-Gage as one of the methods for determining thickness, but it was doubtful whether the order of accuracy of the Magne-Gage went down to 1 per cent or so.

He asked that question because of his own most disappointing experience in attempting to get such a thickness for corrosion tests when he had found that the order of accuracy was very much out of line with that which Dr. Knapp had found. He hoped that Dr. Knapp would describe the technique he adopted to obtain those thicknesses.

The work seemed to suggest that nickel as a deposit was inferior to the composites which was a disappointment and he wondered what had happened to the work described by Pinner at the International Conference in 1954 which considered thousands of samples exposed in a variety of composite combinations and finally came to the conclusion that nickel on nickel type deposits gave the best results. Had that work been progressed?

In a concluding question to Mr. Arnold he would like to know the precise specifications. What were the thicknesses of copper and nickel that he was aiming for ?

Mr. D. E. Weimer (Development Chemist, M.L. Alkan Ltd.) said that in Dr. Knapp's paper, the corrosion resistance of a Ni-Cr-Ni system seemed to be related to the thickness of

chromium, at least on the tests at Kure Beach. Was this related to the freedom from cracking of the chromium deposit.

### Possibilities of Crack-free Chromium

If a completely crack-free deposit could be formed on the top of a nickel coating, this would be an easier answer from a practical point of view. He was investigating a new solution at the moment which it was claimed had a normal operating temperature which produced good brightness, crack-free thickness, good throwing power and other essential properties of bright chromium solutions. If these properties were confirmed in extensive practice, that might well be the answer to the problem of producing a highly resistant protective film on basis metals.

Mr. Arnold had compared the results obtained from using what were essentially basic plating solutions, and under those conditions he did not think either of those systems was likely to produce the optimum results.

As far as the copper/nickel/chromium system was concerned there was no cyanide copper solution available which was suitable.

One of the major faults with cyanide copper solution was the inability of the anodes to maintain the copper concentration which had therefore to be kept in balance by the addition of copper cyanide which was a far more expensive way of adding metal than from the anodes. It was not really fair to compare metal costs based on consumption when some of the metal was coming from the addition of salts.

Considerable advantages could be claimed in favour of acid copper sulphate, such had excellent levelling properties but were very variable. The addition agents were relatively expensive and did not affect the inherent disadvantage of chemical attack in the recessed areas which could only be overcome by a relatively thick deposit. The only solution for copper-plating recessed areas was the pyrophosphate solution.

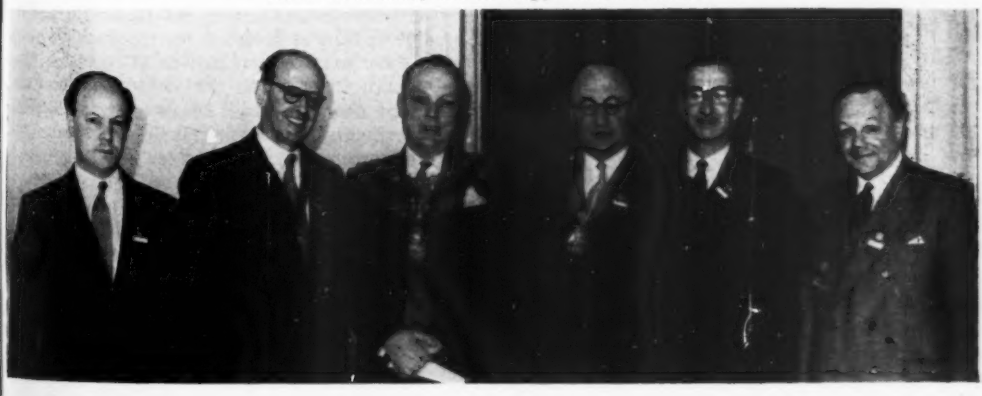
MR. S. W. BAIER (Liaison Department, British Non-Ferrous Metals Research Association) said that it seemed strange that Mr. Arnold should claim to find in practice that by reducing a 2 mil coating of nickel to one-third mil copper and ½ mil bright nickel he got better results, which was so contradictory to all that the research work and exposure tests had established. He wondered whether there were some other factors that had not been brought out, such as the loss of weight of metal at important points in polishing that made the difference.

### Assessment of Costs

There was a danger in dividing costs too simply into material costs and labour costs since in changing from dull to bright nickel one had to consider the extra cost of the bright solution and so on. It seemed that Mr. Arnold was losing a lot of the advantages of the new process by using the same polishing with the bright process and not taking any advantage of levelling. There was so little copper put on that it did not seem to be quite the answer to saving the initial polishing cost and doing all the polishing on the copper. The total savings no doubt quite real in practice, but they seem to be largely tied up with a much better layout, which no doubt was excellent but did not bear out the main contentions in the paper.

MR. N. A. TOPE (Director, Montgomery Plating Co. Ltd.) asked in connexion with Dr. Knapp's paper whether when using chromium plating as an intermediate layer the middle chromium layer would affect the exfoliation and general serviceability of the coatings.

*The Conference was opened by the Mayor of Torquay, Councillor A. L. Goodrich, here shown with the reception committee comprising — left to right — Dr. D. N. Layton, chairman-conference technical sub-committee, Mr. R. A. F. Hammond, immediate past president, Dr. T. P. Hoar, president, Mr. L. S. Lowery, chairman conference social sub-committee and Mr. I. T. Watkins, hon. secretary, Midlands branch.*



# Author's Replies

DR. B. B. KNAPP, replying to Mr. Castell said that chromium directly on the basis metal had not been tried as yet, but it was one of the things he hoped to investigate in the near future. Tin-nickel alloys had not been investigated either, although, probably, they would be advantageous.

No work had been done on zinc-base alloy die castings, although some results he had seen looked very satisfactory. The samples had been exposed to an accelerated test, and there was always a little danger in trying to determine how accelerated tests were going to perform in service.

On the practical technique of the chromium composite : he did not know of any actual use of it as such, but he was very much interested in them and it might not be too long before they would be tried out.

In reply to Mr. Sprague's question about the chosen thickness of one mil, he felt that that was at the lower range of thickness used in the automobile industry, and since concern was mainly with the performance of these coatings on automobiles, it was thought that that was reason enough to select a thickness of one mil. It was difficult to draw very definite conclusions from thinner coatings exposed out of doors ; for instance if samples were exposed in the spring, deep cracks might not develop until the coming winter ; in the fall however it was only a matter of a few months before cracks appeared.

In reply to Mr. Angles, an acid tin bath was used for this work. The flowing was done after the complete deposit was plated and it was done just above the melting point of the tin. It was simply immersed in an oil bath.

With respect to the technique by which this distribution was obtained the panels were plated singly in a small bath, and that made it possible to obtain the distribution given. The plating cell was used at much the same cross-sectioned area as the panel, so that under these conditions there was no build-up at the edges.

The thickness was not measured on the steel panel itself but on a deposit which was plated in parallel on a stainless-steel panel. The measurements were actually made by weight of known areas cut through sections of the foil. The points at which checking was carried out were $\frac{1}{2}$ in. from the edge and the size of the foil measured was $\frac{1}{2}$ in., so half-inches were cut off at various points in the foil.

With respect to thickness, it was true that all the chromium composites were effective in improving the performance of the composite coatings. There was a tendency for the thicknesses in the ranges 5 to 15 micro-in. to show a little better protection than the other thicknesses, and it might be true that this range gave the minimum porosity for the required chromium bath. It was known that in this range the maximum protection was obtained when the chromium was placed on the surface of the nickel layer. It might be that the same amount of porosity would be obtained intermediately, although the first layer of nickel in the dull nickel series was not buffed. In other words, the chromium was plated on the as-plated surface of the nickel. It was, however, plated under conditions which normally gave rise to a bright deposit.

DR. Knapp said that some work was done by the A.S.T.M. on their programme no. 1, in which they were investigating, among other factors such as cleaning and combinations of copper with nickel and chromium, the effect of copper and nickel for the final coat.

In this work it was found with respect to plating nickel to nickel, especially bulk nickel, that the panel showed very marked improvement in certain atmospheres. These atmospheres were the milder ones, one in the country and another at the sea coast. In the industrial exposure there was no difference in the behaviour of these bulk nickel coatings and a single layer of nickel. The explanation however, was not known. In the work recorded some of the findings were confirmed. In one case a layer was interposed and put in an acid nickel chloride bath. In this case there was practically no difference between the behaviour of this double metal coating in a marine exposure and a single layer of nickel.

### Effect of Nickel from Chloride Bath

However, in the last programme a very thin layer of nickel plated from this acid nickel chloride bath was interposed. It was observed that in the milder atmosphere this combination was very much better than a single layer of nickel.

As a result of buffing the first layer of nickel all the pores had been covered. Therefore, the second layer of nickel was probably more sound. and as a result there were no perforations ot corrosion pits, finding a direct path to the basis metal. Consequently, the appearance of rust on the surface was retarded. This result was obtained only in a marine exposure and in the milder atmosphere, and not in the industrial exposure. There was a marked difference in the corrosiveness of the atmosphere as between the two.

As regards the plating of nickel on chromium and whether a good sound method for doing so had been obtained the one described in the paper was treatment in an acid nickel chloride bath, a bath that operated at very low efficiencies. With this treatment excellent adhesion was obtained

there being no indication of any separation between nickel and chromium.

The procedure was simply immersion of the chromium plated article in the bath one minute. After that, the work was made cathodic and was plated at 1 amp per square foot for 6 minutes.

Others had found that it was not necessary to immerse the coating in this bath for the above length of time ; they had been able to get good adhesion by separate plating under those conditions.

As regards the mechanisms in these composites, if there was the basis metal, a first layer and a medium layer of chromium and a top layer of nickel with a final layer of chromium, the chromium extended down to the intermediate layer of chromium. If this layer was cathodic, as it appeared to be, it meant that the layer of nickel tended to corrode anodically. The result was that the pits tended to broaden, and there was a broad pit formed. Very much the same effect could be obtained and it was possible to prevent perforation to the basis metal by means of an intermediate layer of cobalt. Corrosion spread in the cobalt layer and in this case the cobalt was so strongly anodic that it corroded rapidly ; although it protected the nickel itself it had a short life and also it developed blisters.

At attempt to reduce the effect was by dilution of the cobalt with nickel, but it was found that it was necessary to have cobalt/nickel/cobalt composition. This was still too strongly anodic, and it would develop blisters.

The important point seemed to be, as far as the interposed metal layers were concerned, to obtain an alloy that had a potential very near to that of nickel. Probably it did not matter whether it was cathodic or anodic. Chromium was ideal, because there was evidence that under these conditions chromium behaved as a poor cathode. When nickel-plated aluminium was exposed to a salt-spray test holes were obtained that were probably one inch in diameter. When a layer of chromium was put on top of the nickel these holes were reduced down to a few thousandths of an inch. The results indicated in addition that under these conditions chromium behaved as a poor cathode.

* * *

MR. G. ARNOLD, replying to the discussion, said that the obvious comment on the corrosion resistance of nickel deposit was that it was the nickel which contributed to the corrosion resistance but the point that seemed to have been missed was that it was possible that the 2 mil of nickel deposited on the outside surface might be reduced to as little as two-tenths, so that it was essential to watch that very carefully. The presence of the copper in the second method greatly assisted because the nickel plate which was put on afterwards gave exactly the protection that was wanted. So in the first method it was put on and then removed ; in the second method it was put on and left there. Generally speaking, therefore, nickel from the second method gave far greater protection.

Dr. Wernick had asked what thickness of deposit was aimed at and the answer was a deposit thickness which would give adequate protection. If what was being done at the moment was not satisfactory a thicker deposit would be used.

He had been fortunate in being able to visit a number of homes where this product and a number of other products were in use and had been for a number of years. He found that generally speaking the corrosion resistance was very good.

*Abstracts No. 3*

## The Properties of Bright Nickel Electrodeposits in Relation to the Period of Service of the Plating Bath.

*by J. Edwards.**

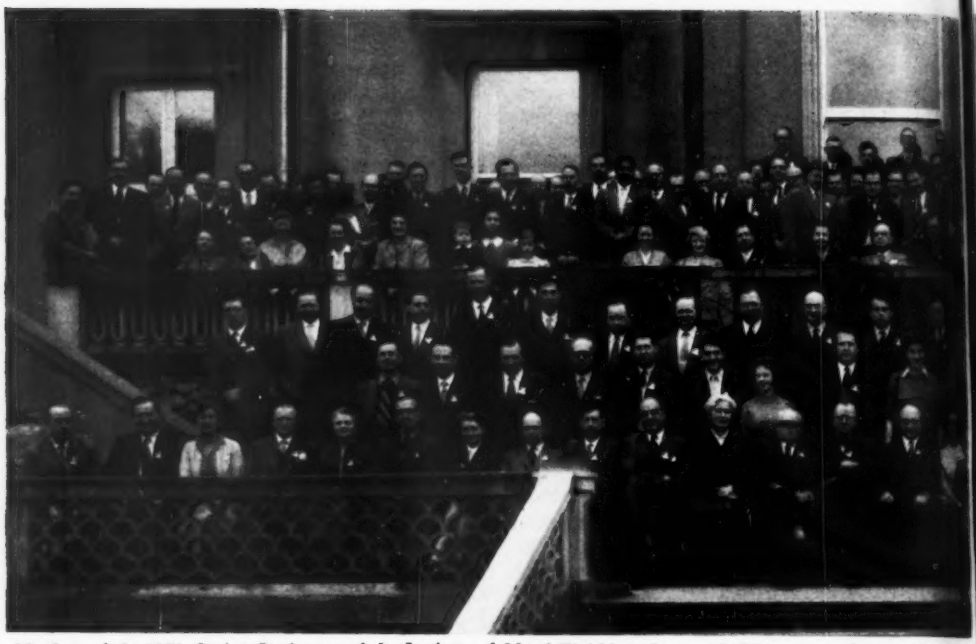
In the work described in this paper two proprietary bright nickel solutions were operated under carefully controlled simulated production conditions, with periodical measurement of the properties of the deposits and of the solutions. Experimental and testing procedure and results are described in detail.

No particular difficulty was experienced in operating either bath for about 1,200 amp/hr per gal. after which the solutions began to produce unacceptable results. Ageing of the solution had significant effect on the brightness, internal stress and ductility of the deposits, stress tending to increase and ductility to decrease. In one solution the brightness range contracted with time, and purification was considered necessary when it became impossible to maintain brightness over the whole surface of the cathode. In the other solution this stage was marked by excessive brittleness of the deposit. Such properties as throwing power, adhesion and microhardness were unaffected by ageing of the solution.

The deterioration in properties appears to be due to the accumulation of organic impurities in the solution, arising more probably, in the light of infra-red spectroscopic analysis, from the decomposition of addition agents than from external sources. This conclusion is supported by the observation that purification of the solution by activated carbon or by extraction with chloroform is effective in restoring the properties of the deposit.

It is concluded from a consideration of the factors determining the concentration of impurities

*Head of Electrodeposition Section, The British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.



*Members of the* 1958 *Spring Conference of the Institute of Metal Finishing photographed between sessions on the terrace of the Palace Hotel, Torquay.*

that it would be more economical under practical working conditions to control the impurity concentration at just below the critical level by frequent partial treatment, rather than to remove almost all organic material from the bath be treatment with activated carbon when it show signs of deterioration. In this way stoppage of work and consumption of addition agents can be minimised.

All the work in this paper is defined in terms of two named proprietary solutions and reference to all addition agents is by their proprietary names. Acknowledgment is made to the two suppliers of the solutions for their co-operation.

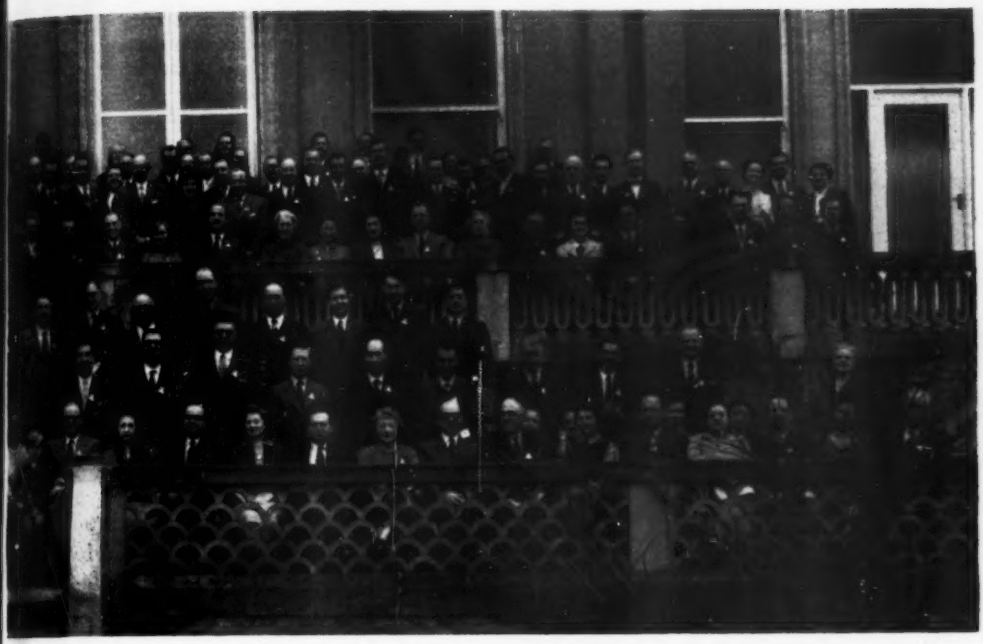
A second part of the paper gives details of atmospheric exposure tests at industrial and marine sites, and accelerated tests in moist atmospheres containing $SO_2$, which revealed no tendency for the corrosion resistance of organic bright nickel/chromium coatings to vary with ageing of the nickel-plating solution.

## Discussion

MR. E. A. OLLARD (Director and Consultant Electro-Chemist, Atlas Plating Works Ltd.) after complimenting Dr. Edwards on the work he and and his associates had done, also complimented the two supply houses who had co-operated in the paper. This was the beginning of a new era ; the people who had hitherto sold the trade various mixtures which all had looked upon with mixed feelings, had now put them in the hands of a neutral observer to find out what really did happen. Dr. Edwards had shown that the solutions did change with time and that this change was due to the accumulation of a certain substance in the solution, though he had not been able to say exactly what it was or where it came from.

That was an interesting point, but there was one point of difference between the two solutions the practical importance of which had not, perhaps, been sufficiently stressed as regards its practical importance. Dr. Edwards had found that when the Super Gleamax solution had reached a certain degree of contamination, he no longer obtained an acceptable bright deposit. Therefore, any plater using that solution would find that phenomenon out and know from observing his deposits when purification was wanted. On the other hand, with the Efco Udylite solution he said that this did not occur and although he obtained a low ductility and high stress, he did not observe any great difference in brightness or brightness range.

There was a paper by Bertorelle, Bellobono and Bordonali in which it was suggested that a certain amount of addition agents were modified by a cathode reaction, and this was possible ; Dr. Edwards had said in fact, that it seemed to be a function of the working time and that these substances were produced by an electrochemical reaction in the cathode.



However, they might be produced, at any rate in part, by some electrochemical reaction at the anodes. On certain surfaces especially, there might be a much higher oxygen over-voltage at the anode than was anticipated. In addition most of the solutions contained chloride, so a certain amount of chlorine might be liberated.

MR. U. F. MARX (Chief Research Chemist, Wilmot Breeden Ltd.) said that he was particularly interested in Dr. Edwards' attempt to draw up conclusions as to where the addition agents go. He might however, have overlooked one source of loss, and that was the insoluble breakdown products which come out on the filters.

As regards organic impurities in the solution, he thought that they did arise in the solution ; because in all solutions he had found the same spectrum of the impurities as Dr. Edwards did.

### Nature of Addition Agents

MR. J. W. OSWALD (Chief Chemist, Fescol Ltd.) said that it was impossible to discuss the degradation products and their possible effects without knowing exactly what chemicals had been used.

Dr. Edwards had to refer to such things as Brightener No. 3 and Non-Pitter No. 4. Unless these were fully known it was not possible to talk about degradation products. However he felt sure that any chemist worthy of the name could find out exactly what the constituents were if he had the opportunity.

Had Dr. Edwards considered the possibility of contamination from the vat linings ? It was rather significant that with the SG solution the current rate was 46,000 amp. hr. in a polythene-lined tank and good deposits were obtained. With 3,900 amp. hr. in a rubber-lined vat trouble was experienced. The permanent cathode baths were also in rubber-lined vats, and there was difficulty there, and in these vats the ratio of square inch of vat lining per gallon of solution was much higher than in the ordinary plating vats. It was quite well known that accelerated action upon rubber linings could give very queer effects.

He also wondered why the peculiar loading was chosen for the hardness reading. It seemed to be unnecessarily low for the hardnesses recorded.

MR. D. E. WEIMER (Development Chemist, M.L. Alkan Ltd.) said that he also was interested to know the reason for the different results between the permanent cathode experiments and those where the over-riders were used. One explanation suggested the rubber lining of the tank as being the cause. However, could the results, as Mr. Ollard had said, be due to different anode current densities being used in the two different set-ups, or could it be due to a different rating of breakdown with the addition agents because of the different current densities being used in the two experiments.

MR. S. H. MELBOURNE (Research Chemist, G.K.N. Group, Research Laboratory) said that Dr. Edwards had written that levelling power determinations would clearly be valuable for some solutions, but methods employing metallo-

graphic procedures would not be feasible in most plating shops. There were, however, other ways of determining levelling, though probably not quite so fundamental and accurate as Dr. Edwards' methods. One of the more convenient methods, and also a direct reading method, was the analysis of surface profile by the use of a gauging method. Probably the most accurate instrument was the Talysurf which had been used for surfaces in plating. Apart from its strength and unavailability, it was not an instrument one would like to have lying about in a plating shop. The high degree of skill required in using it, particularly down irregular surfaces, nade it impracticable for the plating shop, although it was useful for the testing laboratory. There were other instruments working on similar principles, such as the profile tester, which were relatively inexpensive and easier to use. They had the advantage that being directly applicable to the surface, the checks could be done in the components themselves in a non-destructive manner.

The results were not strictly comparable with those obtained by Dr. Edwards, but a good system of quality control could be set up by a person in a responsible position deciding from appearance or other effects the type of smoothness wanted.

MR. J. DIXON (Midland Sales Supervisor, M.L. Alkan Ltd.) said that he would like to speak of his experience with both Gleamax and Super Gleamax.

He had found in operating a solution at something like 160,000 amperes a day that there was a gradual fall off, particularly in ductility and brightness. It could be recovered up to a point by further additions of brightener. His company were using a test for brightener which though not scientific gave a good indication of the efficiency of the brightener content. This was a sodium formate estimation, when the value was 8 oz. per gal. a carbon treatment was given to the solution, after which the sodium formate figure went down to 6 oz. per gal. (the normal figure).

He was not suggesting that carbon removed sodium formate but it removed something that was returned in the sodium formate estimation.

He could always demonstrate that a controlled deposit did not crack or come off.

For the best adhesion of deposits *p*H of 3.8 was found to be the best figure. This involved considerable ion build-up in the solution and after six weeks peroxide treatment of the solution had to be done as well as the carbon treatment.

MR. NEWMAN (W. Canning and Co. Ltd.) said that the tests were conducted on what might now be called fairly early bright levelling solutions and some of the recent improvements in brightener for plating had taken cognisance of the comments Dr. Edwards had made concerning the ability to filter through carbon continuously without removing too much of the addition agents. That was certainly a very attractive way of purifying the solution and keeping it consistently pure. In practice it was found that continuous carbon treatment maintained both the physical properties, ductility and internal stress, at pretty consistent and good valuations.

### Contamination by Rubber Linings

One slight difference his company had found with Dr. Edwards' work on the permanent cathode bath was that in their tests glass tanks were used in order to eliminate any chance of impurity from organic materials, such as rubber linings. The rate of fall of the physical properties or the rate of deterioration was less in the glass tank than Dr. Edwards found in the rubber-lined tank. Therefore, he had to agree with Mr. Oswald that rubber linings could, in certain cases, even though they were well leached and quite old, still be harmful. Nevertheless, they were very widely used and generally very satisfactory.

Concerning corrosion resistance, he thought that recent work had shown the great importance of the over-coat chromium deposit on the corrosion resistance and Dr. Edwards' findings were not at all mysterious. The change in the physical properties of the nickel deposit had a very minor influence on the corrosion picture as compared with the crack and pore pattern of the final chromium layer which was the overriding factor in the corrosion pattern.

DR. S. WERNICK (Consultant) said that most platers would be relieved and reassured by the main point which came out of the paper *viz.* that ageing affected neither throwing power nor corrosion resistance in the deposit. It mattered very little what were the properties, but those two points were absolutely essential. It did, however, seem to conflict with the generally accepted thought that when stress got out of hand in any bright nickel deposit, it would affect corrosion resistance. Perhaps Dr. Edwards would briefly comment on this.

Regarding additions to bright nickel solutions was not the answer to have these addition agents added continuously throughout the life of the bath ?

## Author's Reply

DR. J. EDWARDS, replying to the discussion, said that he was grateful for the remarks about the effect of rubber linings. He was, of course, well aware of the dangers of using rubbers containing harmful materials and he did all he could to ensure that these rubber linings were not to be included in that category. Initially polythene linings were used for a large vat but difficulties were experienced with cracked linings and so they were abandoned.

It was probably true that glass tanks should have

*The amount of administrative work involved in the organization of a large scale conference is not always appreciated by the delegates and thanks were rightly due for their efforts to the permanent staff of the Conference office, Mrs. C. Sieff and Mrs. E. Last, seen here with the Hon. Treasurer of the Institute, Mr. F. L. James, whose retirement after nearly 30 years of untiring devotion to the interests of the Institute has been announced. In the background is the well-known figure of Dr. S. Wernick, Hon. Secretary of the Institute.*

been used for the smaller permanent cathode baths.

It was probably true that addition agents were broken down at the anode at least as much as at the cathode.

Mr. Marx referred to losses of impurity by insoluble material coming out on the filter. He had often observed this in commercial practice, though not in his own work, although he was prepared to believe some impurity was lost in that way. No doubt some was lost by complete decomposition into carbon dioxide or other oxides, but these were relatively small losses, he assumed, and by comparing the practical curve for the increase in impurity in the Super Gleamax bath with the predicted curve from losses by drag-out and so on. it was possible to calculate the amount of material incorporated in the deposit or lost by complete decomposition.

This piece of work was a very large undertaking, and apart from the actual operation of the bath carrying out the tests and so on involved many people and pieces of equipment.

The equipment used for microhardness testing was not appropriate and therefore he had not emphasised it.

Mr. Weimer's comments on the failure of the permanent cathode bath to behave exactly as the pilot plant behaved were interesting. Different anode current densities could affect the result but he was not so concerned about the failure of the permanent cathode bath to produce deterioration exactly matched in rate with that of the pilot plant bath. What was disturbing was the fluctuation in properties which attributed to the fact that the bath was operated for a considerable time virtually without attention ; i.e., without actually plating a specimen other than the permanent cathode in order to see how things were getting along.

He was surprised to hear Mr. Dixon's remarks about his experiences, although he did not think there were any points that he was called upon to comment on except possibly his use of $\not{p}$H of 3.8. Experience with Super Gleamax had shown that this was too low.

He was pleased to hear Mr. Newman say that some suggestions had been taken note of with regard to the operation of bright nickel solutions and that success had been met with in using continuous carbon purification.

It had been known for some time that thicker deposits of chromium could be applied free from cracks and with full brightness by using increased temperature and current density.

It had often been claimed, that the use of these deposits led to better corrosion resistance. At a time of severe nickel shortage six or seven years ago people were urged to take advantage of this fact, and the reply generally was that the use of longer times on chromium plating with higher current densities requiring better contacts and more accurately produced equipment, rectifiers and motor generators, precluded the adoption of this method. Interest was now reviving following some work in America, and further work was being undertaken in this country.

**Influence of Stress on Corrosion Resistance**

Dr. Wernick commented that results reported in the paper conflicted to some extent with the general idea that stress getting out of hand affected corrosion resistance. It was perfectly true that if the stress became too high in relation to the ductility, cracking of the nickel would occur. There was no evidence, however, that the stress had any effect unless that stage was reached. Even cracking of the chromium which was observed in these tests, of something like 50 per cent was not related to the stress in the nickel deposit nor to the age

of the nickel solutions. The occurrence of this cracking seemed to be entirely random. It was assumed that the operating conditions were with the thickness conditions of chromium deposits practically on the borderline of crazing of the chromium.

It was remarkable that in the sulphur-dioxide tests carried out, the proportion of over-riders which showed crazing chromium after 96 hours was almost exactly the same as the proportion showing crazing in exposure at Euston in a severe industrial atmosphere with conditions practically as bad as this in $SO_2$. The crazing which occurred at Hayling Island was very much less, though it increased with time after the one-year exposure tests reported in the paper.

*Abstract No.* 4.

## Bright Nickel and Levelling Power.

*E. Bertorelle*, I. R. Bellobono* and C. Bordonali.**

THE introduction to this paper reviews some of the work carried out to investigate the mechanism of the levelling action and brightening action of nickel plating solutions containing various organic addition agents. It goes on to describe some work by the authors in which they studied the cathodic phenomena which occur during bright nickel plating. The action of organic brighteners has been considered as due to the possibility of some functional groups in the organic molecule interacting with free orbitals of the nickel ions, thus minimising the size of crystalline growth centres in the process of electrodeposition. Neutralisation of these functional groups is almost always followed by the disappearance of the brightening action as has been shown with N—alkyl substituted saccharin.

The fully brightening action of some amine oxides shows, however, that the possibility cannot be excluded that cathodic reduction of the addition agent may play an important part in the cathodic deposition process.

The authors also describe their method of producing a surface with a standard profile for the purpose of measuring the distribution of electrodeposits. The technique adopted consists of winding a metal wire of suitable small diameter on a metal tube. After electrodeposition the specimen is embedded in synthetic resin and sectioned longitudinally on the diameter of the tube. This gives a micro profile of pseudosinusoidal shape. By plotting graphically the amplitude of the pseudosinusoidal curve against the thickness of the electrodeposit on the peaks of the profile it is possible to arrive at a very reasonable comparison between the levelling powers of various electrolytes containing different organic addition agents.

The authors conclude in the light of their experimental work and in agreement with other workers in this field, that there is no correlation between the levelling and brightening activity of organic addition agents. It is suggested that levelling action may be the result of a differential adsorption of addition agents in the diffusion layer on the cathode surface. This fact may cause a differential inhibition which would then favour a faster deposition in the valleys than on the peaks of the profile.

*Dept. of Industrial Chemistry, University of Milan.

*Abstract No.* 5.

## Stress in Nickel Electrodeposits

*T. P. Hoar* and D. J. Arrowsmith**

DESPITE considerable investigation largely aimed at the development of practical methods of reducing tensile stresses in electrodeposited coatings, little is known of the detailed stress distribution in deposits, or of the manner in which stresses are produced and still less of the mode of action of stress reducing action.

In a previous paper the authors describe a new instrument for the measurement of the stress developed at any stage in the growth of an electrodeposit and the present paper describes the use of this instrument in studying the development of stress at the various stages of growth of nickel deposits on steel, both from a plain Watts bath and from baths containing a variety of typical stress reducing agents over a range of concentrations.

Results show that tensile stress developed in deposits from the plain Watts bath is reduced and finally made compressive in a continuous manner as the concentration of stress-reducing agent is increased. The " instantaneous stress " (the stress in any small increment of thickness) becomes nearly constant with thickness ; it is not markedly influenced by the temperature or current-density of deposition.

The results are interpreted by means of vacant-site and dislocation theory. Tensile stress appears to result from the formation of an oriented array of edge dislocations initiated by surface vacant sites, the overcrowded sides of each dislocation being the side remote from the growing surface. Compressive stress results from stress-reducing molecules being adsorbed at surface vacant sites and so initiating edge dislocations of the reverse orientation. The ratio of the concentrations of the

*Department of Metallurgy, University of Cambridge.

*Discussion over coffee during the break in the morning technical session between (left-to-right) Mr. A. W. Wallbank (Managing Director Imic Plating Co. Ltd.) Dr. B. B. Knapp (Research Laboratory, International Nickel Co. Inc., Bayonne, U.S.A.) Dr. S. Wernick (Hon. Secretary, I.M.F.) and Mr. H. C. Castell (Development Officer, The Mond Nickel Co. Ltd.)*

two types of dislocation then determines the magnitude and sign of the stress, which thus changes continuously with the degree of adsorption.

*Abstract No. 6.*

## Surface Preparation and Porosity in Electrodeposited Nickel

*P. A. Brook**

WORK is described which is designed to establish the presence or absence of a correlation between the method of surface preparation used and the subsequent porosity of a nickel coating deposited on the surface so prepared. Eleven different preparatory sequences were used, varying in certain particulars and the porosity of the nickel deposit was measured by an autoradiographic technique using radioactive nickel. The plating sequence involved deposition of 0.0001 in. of $Ni^{62}$ having an activity of 78 μc per gm., followed immediately by deposition of about 0.001 in. of non-active nickel from a Watts nickel bath, on to inch square specimens of high conductivity copper. Microsections of typical coatings produced in this way show complete continuity of crystal structure between active and non-active nickel, from which continuity of any pores present is reasonably assumed.

Pore counts were made by leaving the plated specimens in contact with photographic plates and from the results, after statistical analysis, it is concluded that the porosity induced by the nature of the surface layer is only affected by the changes in the gross characteristics of the surface and that methods of surface preparation employed in this work do not influence the porosity in a deposit of the thickness used.

* Department of Metallurgy, University of Nottingham.

*Part of the delegation representing Albright and Wilson Ltd. seen here includes (left-to-right) Mr. W. K. Bates (Divisional Sales Controller), Mr. F. Wells (Technical Service Dept.) and Mr. P. F. Walmsley (Sales Manager, Metal Finishing Dept.)*

# Discussion

DR. J. EDWARDS (Head, Electrodeposition Section British Non-Ferrous Metals Research Association) said that he found the paper by Bertorelle, Bellobono and Bordonali rather confusing ; mainly he thought the language difficulties were partly responsible, but even allowing for that it was very difficult in some cases to know precisely what views the authors were putting forward.

In addition, he wondered why the discussion section was so slight. It consisted of only two paragraphs. The first made the point that levelling and brightening were distinct properties, and the second related to a finding by Watson and himself that levelling agents were incorporated to a greater extent on the peaks than in the recesses of level deposits.

The authors added, " Adsorption is perhaps greater in high-current-density areas in consequence of a cataphoresis phenomenon ". This did not make sense, because under levelling conditions the peaks of a rough surface were not high—but low-current-density areas, because there was more deposit in the valleys than on the peaks.

Certain evidence was offered to show that the reason for this type of metal distribution lay in diffusion control. In fact, the authors had stated so in the paper.

An ingenious method had been used for producing standard surfaces for levelling determinations. Dr. Layton referred to the narrowness of the valleys which was certainly a criticism of this surface. Another point that worried him was the danger of cleaning solutions, for example, being trapped in the cathode. On the other hand, there was the advantage of permitting a surface of a given form and size to be reproduced accurately and furthermore it made it possible to vary size without varying shape.

Some of the authors' criticisms of forms of surfaces used by other investigators were not valid, and it was hardly fair to do so and also to postulate for the sake of argument that grooves 20 microns wide and 200 microns deep had been chosen. No one, as far as he knew, used grooves of these dimensions.

As regards brightening he thought that the authors' plan of investigating groups of related substances was likely to yield further illuminating results. He would, however, urge them both in this work on brightening and in the work on levelling to pay careful attention to the conditions under which their experiments were carried out, particularly with regard to concentration and current density.

It was difficult to know what to make of the illustration in the paper which showed levelling curves for various substances, without knowing what were the concentrations of addition agents and what were the current densities. It was necessary also to know how these particular conditions were chosen and whether they were supposed to be the conditions under which the best levelling was obtained. Levelling was very much dependent on concentration and current density, and even related substances might give optimum levelling under quite different conditions.

**Effect of Organic Substances on Stress.**

Referring to the paper by Hoar and Arrowsmith Dr. Edwards said that his colleague Mr. Watson had been engaged for some time in making measurements of the effect on stress of various organic substances, and it would be useful to have Dr. Hoar's comments on some of the variations observed to see how far they could be reconciled with his theory.

Although the theory was very attractive, it was clear from what Dr. Hoar said in introducing the paper that he did not regard the relatively few data so far produced as in any way established. It was necessary to know more about the incorporation of substances and the factors controlling the development of stress in the absence of organic addition agents.

Very often it happened in his own work that the stress was reduced with increasing concentration of addition agents, rather as Dr. Hoar said. The stress might come down across zero stress without showing any discontinuity and then in some cases if the concentration was increased further it simply attained a constant value. In other cases, however, it began to rise again and could reach quite high tensile values. In yet other cases, it might come down again, although this was probably due to cracking causing stress relief.

Yet another instance was provided by substances which, starting at the same stress, simply increased the stress continuously with increasing concentration, again with a possible turn down when very high stresses were reached, possibly due to cracking. Many of the substances added to nickel baths to promote levelling or brightening reduced stress at least in relatively low concentration. A number of the substances falling in one category or the other were accompanied by an increase in ductility. However, materials with the lower stress in bright nickel baths often gave increased ductility, or at least had no immediate effect on ductility.

It was interesting that substances of that kind—saccharin was the best known example—had no appreciable effect on cathode potential, and, although not conclusive, appeared not to be incorporated in the deposit.

Dr. Hoar had attempted a tentative explanation of compressive stresses in zinc and cadmium deposits

*Mr. Bryn Jones (left) Plating Superintendent, Platers and Stampers Ltd., chats with Mr. R. A. Wilding, Process Superintendent, Bristol Aero Engines Ltd.*

from solutions not containing organic additions. He had said it was conceivable that the compressive stress in zinc arose through the co-deposition of very small entities of the oxide or hydroxide that were able to create " inverted " edge dislocations. Would he be prepared to allot any role whatever to basic material known to be incorporated in nickel deposits ?

Mr. Brook's paper was a welcome sign of the further application of radio-active isotopes to the study of eletrodeposition problems, but he would like to know precisely what kind of discontinuity Mr. Brook was looking for. What size of discontinuity did he think his technique was capable of detecting ?

The beginning of the introduction to his paper was rather misleading in which he stated that : " Nickel is relatively resistant to corrosion. An electrodeposit of nickel on a more corrodible base can protect the latter to an extent which depends on the porosity of the nickel " and so on. He thought that was not true. In most cases a considerable amount of nickel was corroded before extensive attack on the basis metal occurred.

It had been shown in Dr. Knapp's paper that a nickel deposit failed very often by pitting which need not penetrate the deposit. When it did, extensive attack of the basis metal occured underneath, and this was usually the case with a reasonably thick nickel/chromium deposit on top of steel or another basis metal that had been exposed to the atmosphere.

It might be that this did occur at points of weakness in the nickel or the chromium ; but even if the weakness took the form of a pore in the nickel, it was clear that the pore had only to permit corrosive liquids to penetrate to the basis metal without attacking the nickel.

He would have thought it likely that such pores, if they existed, would not be detected by the radiographic technique. On the other hand, there were what were called gross pores, fairly large holes in the deposit caused by solution or basis metal irregularities, bad preparation sometimes associated with pits or undulations torn out of the coating during polishing. This could lead to rapid attack of the basis metal and would be detected by Mr. Brook's technique. But he would be rather surprised to find in a deposit 0.001 in. thick ten or fifteen or more such pores

*Past President of the Institute and an I.M.F. Gold Medallist, Dr. G. E. Gardam (Aluminium Laboratories Ltd.) with Miss D. Pile (Technical Information Officer Metal Finishing Association) and Mr. S. W. Baier, (Liaison Dept. British Non-Ferrous Research Association).*

per square inch, so he was rather mystified. He hoped Mr. Brook would be able to make some calculation of the size of discontinuity which he would expect to detect.

In one of the papers Mr. Brook referred to (Ogburn and Hilkert) it was calculated that the smallest pore that could be detected was about 0.001 in. across. That was rather a large hole in a deposit only about 0.001 in. thick. These authors used a different technique and irradiated from behind through the basis metal and the deposit, and Mr. Brook's technique might be more sensitive.

### Influence of Grain Size

MR H. D. HUGHES (Metachemical Processes Ltd.) said that Dr. Hoar stated that deposits were made on to shim steel, and he did not define the condition of that steel in relation to grain-size or orientation. His own work had been of a practical nature, and had been concerned with the production of thick layers of nickel (up to from 0.01 to 0.015 in. of electroformed nickel) with the desired properties of high hardness and a combination of resistance to deformation and to cracking under high impact load. None of the deposits which gave hardness values of the order required, using solutions containing addition agents, would withstand the impact loads, and attention was therefore directed to another possible method using the influence of the basis material grain-size.

Steels taken from the middle of the standard grain-size range had an average approximate grain diameter of 0.003 in. Consequently, a conducting material was prepared with an effective grain-size of less than one micron. This was done by processing finely divided graphite with a preferred orientation. Several years ago in a paper by Frank it was mentioned that graphite apparently had no effect on the deposit, but he was sure he must have been referring to block or bulk graphite which was completely random.

Using a standard Watts nickel solution operating at 35°C. and an average current density of 15 amp. per sq. ft., the following comparisons were obtained. The hardness of the nickel deposit compared at 480 to 520 V.P.N. on the fine base with 120 to 160 on to the stainless steel of normal grain-size. Tensile strength was in the same order and elongation was in reverse proportion. The structure of the material could not be examined by photo-micrography but after crystallization at 1000°C. throughout the deposit showed a steady growth from an extremely fine up to a large grain size. This was quite regular and agreed partially with microhardness tests across the section which showed a slight but definite loss in hardness occurring with increasing thickness.

More important for purposes of the discussion of this paper was that the fine-grain nickel was always in compressive stress, while nickel deposited on steel was in tensile stress, deposited in exactly the same time and the same bath in the same conditions.

### Scale of Levelling Phenomena

Mr. U. F. MARX (Chief Research Chemist, Wilmot Breeden Ltd.) said that Professor Bertorelle, in his very elegant experimental technique, had used what he called a pseudosinusoidal profile which was very large in comparison with the few layers in which it was suspected that a lot of the levelling and brightness process took place. In fact, the initial depth of his variation was 50 microns. The commercial plater when he was concerned with the levelling solution usually tried to reduce his inhomogenieties to the order of not more than one micron. The question was whether it was justifiable to consider that the phenomena which happened in a gap 50 microns deep were at all comparable with those which happened in one of one micron depth and which were probably wider proportionally than those which Professor Bertorelle had worked on.

MR. D. D. JONES (Research Student, Metallurgy Department, University of Swansea) said that Mr. Brook in his paper had referred to the ferricyanide reagent used in the ferroxyl test, which had been found to attack nickel. Thorne and Addison had recently reported unpublished work in which nickel foil had remained unaffected for days in pure ferricyanide. Similarly, pure sodium chloride had no effect on the nickel. Attack set in with combinations of these two substances.

Reference was also made in the paper to the technique of using either an external source of radioactivity or an X-ray generator as a source of emanation which had been tried, but with unsatisfactory results. Was that because the maximum thickness of the basis metal to give satisfactory radiographs must be less than .003 in.

One advantage of the technique using an external source was that it did away with the intermediate layer of radioactive metal which could affect the porosity of the finer non-active coating, Also in the actual technique there was an interruption of the plating between the non-active and radioactive parts which might be very small, but which might have an effect on the porosity of the subsequent layer.

### Interpretation of Radiographs

It would be helpful if Mr. Brooks would enlarge on the interpretation of the radiographs. They seemed to be difficult to interpret, as Wolff had stated elsewhere that the primary disadvantage

*It is reasonable to suppose that aluminium figured largely in this conversation between Mr. A. W. Brace (Head of Finishing Section, Aluminium Laboratories Ltd.) and Mr. F. C. Porter (right) (Metallurgist, Aluminium Development Association).*

of the method seemed to lie in the subjective examination which depended on the skill of the examiner.

Mr. Brook had stated in the conclusion to his paper that methods of surface preparation employed in that work did not influence the porosity in a deposit of the thickness used. Work by Hothersall and Hammond, and Evans and Shone indicated that the effect of surface roughness on porosity would be greater at smaller thicknesses. Was Mr. Brook carrying out experiments on the effect of varying the thickness of non-active nickel on the number of radiographic spots, keeping the thickness of the active layer constant, and would he expect the results to conform to the well known hyperbolic graph of porosity versus thickness ?

Mr. G. Storey (Student, University of Birmingham) asked Dr. Hoar whether if tensile stresses found in thin layers of deposits were due to the freezing in of residual tensions, since the interfacial tensions did not vary very much from one metal to another, it would not be expected that the stresses in thin deposits would be of the same order, whatever the metal considered.

It was well known however, that there was an order of magnitude in the difference between the stresses measured ; for example, copper and silver show 3 tons per sq. in. whereas nickel, chromium and iron give 30 tons per sq. in.

Dr. Hoar had suggested that perpetuation of vacancies might occur through the deposit, but a vacancy was surely a very energetically favourable site to accommodate an atom, since in such a position it would satisfy many more bonds than would appear on the surface.

The Chairman (Mr. R. A. F. Hammond) said that it was stated in Mr. Brook's paper that for the methods employed surface preparation had no effect on porosity in a deposit of the thickness used. This was supported by results on a wider

*Regular supporters of the Finishing Conference over the years have been Mr. G. G. J. Adey (General Manager, Margam Electro Finishes Ltd.), Mr. H. Roskrow (The Climax Rock Drill and Engineering Works Ltd.) and Mr. and Mrs. D. M. Lyness, (Lyness Bros. Ltd., Belfast).*

range of electrodeposits by Blum and his co-workers. Nevertheless, he found the result surprising.

The difference between, a mechanically polished and the electropolished surface might well be a case of the difference in surface crazing. Wide discrepancies in porosity was shown in many of the series which raised the question of whether the autoradiographic porosity test was itself reliable. Did it function for deviating pores or only for those pores which presented a straight uninterrupted path through the deposit ? Had any attempts been made to check the radiographic results by conventional chemical porosity tests ?

If the test was reliable, how did the author account for the wide variability within the series ? Could that be due to variations in the number or size of oxide inclusions in the tough-pitch high-conductivity copper used by Mr. Brooks ?

Had any attempts been made to correlate or compare the mean density of inclusions per unit of the area with the typical mean density of pores after plating ?

## Over-efficiency of Cleaning

DR. S. WERNICK (Consultant) suggested that Mr. Brook's main finding that porosity was independent of the method of preparation derived from the fact that most methods for removing grease probably achieved a minimum degree of cleaning which was satisfactory. All of the various cleaning techniques which Mr. Brooks had looked at were too good and led to the somewhat negative result which was unfortunate, because it provided no yardstick to judge any of the cleaning techniques by. Perhaps if he were to try some of the proprietary cleaners, he might produce some occasional pores.

DR. H. J. PICK (Lecturer, Department of Industrial Metallurgy) commenting on the experimental technique described by Mr. Brook said that it appeared that a sharp radio-graphic image of a pore would only be obtained if it were perpendicular to the surface, irradiated by a beam of radiation parallel to the pore itself. Only under these conditions would there be a very marked difference of absorption in the rays coming through the pore and through the solid metal in normal radiographic technique. In micro-radiographic technique X-rays with an energy of 35 kV were customarily used.

If this picture were true and a pore which was inclined to the surface was unlikely to show up except in a very diffuse way, the other difficulty which might arise was that if the porosity were caused by some fault in the surface itself, and the radioactive nickel were not deposited, there would be no source of radiation for darkening the pore which was continued through the subsequent deposit. That might lead to some difficulty in picking up discontinuities of that type.

MR. S. W. BAIER (Liaison Department, British Non-Ferrous Metals Research Association) referring to Mr. Brook's paper said he was not quite clear as to the relationship of the porosity. Was the nickel 0.001 in. thick and the order of pores per square inch 3. 4, 8 or 10. When Hammond and Hothersall referred to the porosity of nickel plating on steel, the impression was given that with a thickness of 0.001 in. on steel porosity was not present to any extent, and what was present was caused by the surface of the basic metal.

He was sure that in those days one would have said that any reasonable nickel deposit plated as, say, 0.003 or 0.005 in. on copper, prepared by any reasonable method, would be non-porous.

Was there something quite different about the radiographic technique i.e., was it really testing pores at all or was it showing, for example, crystal boundaries.

It did not seem correct to have, with the type of preparation that was used, unless there was something queer about the basic metal, any appreciable porosity at all in any of these samples.

MR. E. A. OLLARD (Director and Consultant Electro-Chemist, Atlas Plating Works Ltd.) asked Dr. Hoar whether he had considered the possibility of depositing on what in the trade was sometimes called a film surface, a surface with an oxide or some other coat, so that the deposits would not adhere ?

He thought that, in general, by using organic materials and heat treating the deposit trouble was bound to arise. Careful purification of the solution to make it free from organic or other foreign material prevented defects arising.

## Measurement of Porosity

MR. H. SILMAN (Director, Electro-Chemical Engineering Co. Ltd.) said that the definition of porosity could be very largely determined by the method used for assessing it. He did not believe that it was possible to have an absolute measurement of porosity.

In the paper by Mr. Brook there was a list of objections to the various methods employed. The ferroxyl test resulted in corrosion which created porosity. It might be argued that the gaseous diffusion test was absolute, because if there was a pore, the gas would penetrate through it. But even that did not follow, because it might well be that the inclusions in the deposit in the form of loose particles which were known to occur might allow gas to diffuse through so causing the appearance of a pore.

In the same way, the results obtained in the

*This convivial party includes (right to left) Mr. A. C. Benning (Managing Director, Harshaw Chemicals Ltd.,) Mr. Bryn Jones ; Mr. E. J. Blewitt (Chemist, Wilmott Breeden Ltd.) ; Mr. J. W. Weaver, (Assistant General Sales Manager,) Mr. G. C. Hart (Chemist) and Mr. R. T. F. McManus, (Technical Service Manager Harshaw Chemicals Ltd.) In the foreground are left-to-right Mrs. Benning, Mrs. Weaver and Mrs. Blewitt.*

paper, which were of a fairly high order of porosity, might well be determined by variations in the "penetrability" of the deposits.

By the radio-active process, therefore, he tended to regard measurements of porosity as being empirical and related to the type of technique used. One should not take too much notice, therefore, of the figures themselves, when comparing one process with another. If a particular method of measuring porosity was consistently employed, comparable results could be obtained. It could be called porosity or anything else. He preferred to call it the measurement of the penetrability of the deposit under conditions of corrosion.

Care was required about the use of the term "pore", because there was no indication that pores in the sense of true holes going right through a deposit, did exist to any large extent when thicknesses of the order of those described in the paper were reached.

MR. H. D. HUGHES (Metachemical Processes Ltd.) said that he hoped that Dr. Hoar would agree that the changes he had described previously could be obtained from the control of the grain-size and orientation. For any quantitative results obtained from the authors' method, even though they were working on smaller thicknesses and on smaller possible variations in grain size, to be effective the control of the basis material was imperative. Qualitative results and comparative results would require control from sample to sample. Quantitative results were required on the measurement of the grain-sizes, and some definition of orientation was required before the results were published.

On the effect of addition agents, his experience tended to confirm the work on this subject. A proprietary addition agent was used on a small number of experiments, and using the micrographic method there was a reduction in compressive stress. There was an increase in hardness, taking nickel up to 800 to 900 V.P.N. with a big

*Mr. E. W. Mulcahy, Managing Director, (Chemical Engineering Construction (Pensnett) Ltd.) and Mrs. Mulcahy, are here seen entertaining Mr. and Mrs. G. Hopkins, (Chemical Engineering Construction (Pensnett) Ltd.,) and Mr. and Mrs. John Hooper, (Metal Finishing Journal).*

reduction in flexibility and impact resistance. The experiments were discontinued for that reason.

## Author's Reply

DR. D. N. LAYTON, replying to the discussion and referring to Dr. Edwards' remarks that the concentration of the addition agents and the current density were important, since they markedly affected the degree of levelling measured, said that the paper by Bertorelle *et. al.* was a little too condensed, in that it did not describe the experimental work very fully. The authors menttioned fairly early in the paper that the graphs were drawn with the addition agents at their optimum concentrations. If that remark was really justified, they had clearly been embarking on many years of intensive experimental work which was dismissed in one sentence. Since they did say that the addition agents were at their optimum concentration, the statement must be accepted.

DR. T. P. HOAR, replying to the discussion, said that Dr. Edwards rightly pointed out that the paper dealt with relatively few results. Eight-six experiments were reported in the paper, but several hundred were carried out. Also there was a great deal in the literature on the measurement of overall stress which made the point he was trying to bring out *i.e.* that stress could be changed over in a continuous way from tensile to compressive stress by the addition of certain addition agents.

He agreed with Dr. Edwards that if too much of the stress-reducing agent were added it might become a stress-increasing agent. There was no question but that several effects arose with any one substance ; not only that, for as well as, brightening, levelling and stress reduction or increase, any one or other of these properties might be altered in a continuous way. In certain cases there was first an increase and then a decrease, then another increase and so on.

He was not sure that he agreed that saccharin had no effect on cathode potential. He thought that in a paper to the Institute some years ago it was shown to have a certain effect. He was prepared to agree that saccharin was not incorporated to any extent in deposits. He thought that it became absorbed and desorbed rather quickly but at the same time during deposition there was undoubtedly an effect of saccharin in stress reduction.

### Compressive Deposits

As to the possibility of making compressive deposits in nickel without organic additions, he felt that it could be done. The compressive deposits obtained by Mr. Hughes might be due to operating the solution ar a reasonbly high *p*H ; in fact the compressive nickel was obtained from a plain Watts bath with a *p*H of 5.2. Undoubtedly some nickel hydroxide or oxide would be obtained and there might have been some in the deposit which a cted asstress-reducing agents. Dr. Hoar thought that he would have found the same thing with his Watts bath, but it was deliberately operated at *p*H4 throughout in order to obtain the minimum amount of oxide formation consistent with the minimum amount of hydrogen evolution which was thought might upset the cleaning effect of the nickel deposition itself. If a Watts bath was operated at a high *p*H there was incorporation of nickel hydroxide, and quite apart from any other effect a much lower tensile or possibly even compressive stress might be produced.

With regard to the preparation of the steel basis metal to which Mr. Hughes called attention, a fairly good alkaline degrease was used with a very light pickle. When the copper flash was put on before the nickel, no effect on the subsequent stress was noticeable. Nickel plating after a copper flash on this steel gave precisely the same results, whether it was compressive or tensile, as though the flash was not there.

He was fairly confident that under his own conditions (not, he felt sure, Mr. Hughes') after the " steady-state stage ", had been reached nickel was deposited on nickel, and the grain size had no very great effect.

Continuing Dr. Hoar said that at 1000°C there would be recrystallization of the deposit. Also Mr. Hughes' deposits were similar to his and everyone else's in having a very fine grain-size indeed in the as-deposited condition, which was important from the point of view of stress. If there was recrystallization at a high temperature the stress relationships and the dislocations that possibly caused them were completely altered.

He was interested to see that Mr. Hughes' deposits were very hard. That again led him to think that quite a lot of material was incorporated that was not metallic nickel. He did not see how there could be metallic nickel of that hardness without something in it which prevented the slip obtained with ordinary nickel.

With regard to Mr. Watson's point that substitution of one atom in a stress-reducing agent, *e.g.* S for 0, in substituting thio-carbonyl for carbonyl groups, could have a very large effect, of course it did, because the adsorption of thio-substances was always a lot greater on any surface in a general way when the same substance contained enough oxygen ; or thiourea for urea or any similar substance. The fact that this major effect was obtained did not surprise him. He had tried thiourea, but had not published the results because they were peculiar. The stress reduced and increased again in the way Mr. Watson and Dr.

Edwards had observed. But he also found there was a lot of decomposition with formation of hydrogen sulphide with thiourea at *p*H 4 and thought the results were not significant.

With regard to the surface tension of metals, most metals gave surface tensions in the range of 250 to 2,500 dynes per cm, and the fact that there was far more stress in nickel, iron and cobalt deposits than in silver and copper was entirely consistent with and supported the present idea. He had said that only a fraction of the stress could be "frozen in". The harder the metal, the more effective was the "freezing-in" process. With relatively soft metals like silver and copper it would be expected that a small amount of "freezing in" would occur at the same current density, with a lot of "freezing-in" in the case of the harder metals, nickel, iron and cobalt, because the equilibrium between the surface and bulk would be more nearly achieved for copper and silver than for the harder metals.

Mr. Storey's point about the perpetuation of vacancies was a good one. At first sight, a vacancy on the surface would be thought to be just the spot for an atom to "sit-down" in. So it was from point of view of the most stable position. But from the point of view of the position it would go into kinetically this did not occur at all, because it might need more activation energy to go into a hole in the surface than to sit down outside the hole. It was a matter of kinetics rather than equilibrium. It was reasonable to postulate the perpetuation of vacancies in the formation of edge dislocations.

The question about depositing on an oxide film surface was interesting. He had not done any on stainless steel or anything similar. If a nickel deposit was stripped from such a stainless steel and it lay flat and did not curl up one way or the other, he would have thought that, this was good evidence that the overall mean stress was nil. He saw no reason why it should not be if, indeed, operation was at *p*H 5. He operated at *p*H 4. He doubted whether it was possible to get a pure metal deposit which had not some tensile stresses. He thought that it was the oxide which was "wedging it up".

MR. P. A. BROOK, replying to the discussion, said that he would attempt to deal with the apparently high values of 13 and 14 pores per square inch. In most nickel plating there was a disturbed solution but his own solutions were not disturbed by stirring etc. One reason for not stirring was the difficulty of getting the conditions of stirring exactly the same on every occasion. But there was no doubt that some gas pores did form.

Another reason for the apparently high values was that if there was a discontinuity of some description going about one-third of the way through a deposit, the plate deposited would be increased by a factor of two over the background. This was quite sufficient to pick up and count as a full pore.

The interpretation of the results, as mentioned by Mr. Jones, was indeed difficult, but the only alternative to putting them on the screen and counting them was the very difficult and tedious scanning with a micro-photometer. These factors would easily account for the high values.

With regard to the measurement of pores, with a deposit of one-third thickness, there would be n pores per square inch, and pores would be visible to a lesser extent but nevertheless they would be visible in a deposit 0.001 in. thick. As regards the type of discontinuity, Mr. Silman did suggest the correct answer.

All the methods of measuring porosity were empirical and the results depended to a great extent on the method of measurement. All he could say was that he recorded anything which came through the X-ray illumination.

Mr. Jones mentioned the ferricyanide reagent which always attacked nickel. The solution was, of course ferricyanide/chloride solution.

*Photographed at the Conference Dance are left-to-right Mrs. W. Stein, Mons. L. Berthollet, Miss M. Florey, Dr. D. N. Layton, Mrs. A. W. Wallbank, Mrs. W. F. B. Baker and Mons. M. Corfu.*

Mr. Jones mentioned the use of an external source. The probable reason for the results was that Mr. Brook was using a much thicker copper basis.

Mr. Jones had suggested that the presence of the radio-active nickel would affect the porosity of the nickel ; it was difficult to see precisely how this could happen as the chemical and physical behaviour was so little different that nothing could be expected on that score.

The whole point was that he could not find a trace of discontinuity at all between the two metal layers. Surely if the radio-active nickel had some effect on the porosity there would have been a discontinuity of some description at the boundary.

He had made no attempt to check his results with other methods of porosity measurement, but this was under consideration.

As to perpendicular pores, surely the point was that it did not matter much. There would be some pores perpendicular and some at various angles to the surface. These would be statistically distributed about a perpendicular line and he was convinced that the proportion of pores in quite a small angle could be worked out quite easily. It did not matter whether he took the ones not perpendicular to the surface as long as he took a statistical sample, which was what he was trying to do.

The main criticism of the paper appeared to be that the results were high, but he did point out in the introduction that they were meant to be comparative and not absolute.

Several speakers had said that they were surprised that surface preparation had no effect on porosity. But it was pointed out that this could be explained easily by the fact that the surfaces used were too clean.

*Abstract No.* 7.

## Methods of Testing Anodic Coatings on Aluminium

*by A. W. Brace, and K. Pocock**

THE absence of effective methods for checking the quality of anodic coatings has made it difficult to achieve improvements in technique, since—particularly where resistance to atmospheric corrosion has been required—outdoor testing over prolonged periods has been the only method of assessing the characteristics of a coating. With the introduction of certain items of bright anodized trim on current automobile production models the availability of suitable acceptance tests has become a pressing necessity.

*Chemistry Division, Aluminium Laboritories Ltd., Banbury, Oxon.

While film thickness is an important factor in determining corrosion resistance of anodic finish the recommended British Standard method of measuring film thickness, which involves weighing of a specimen before and after stripping the coating, is unsuitable for spot checking of components. Furthermore, corrosion resistance is also significantly affected by the conditions under which the coating is sealed.

The requirements for methods of acceptance testing are listed as

(1) a means of indicating by a simple non-destructive instrument the thickness of the coating.
(2) a test, preferably requiring only a 24-hr cyle, to check the efficiency of sealing.
(3) a corrosion test which takes into account the effects of thickness of coating, purity of basis metal and efficiency of sealing, and
(4) in some cases where hardness of film is important, a rapid method for testing abrasion resistance.

The paper goes on to describe various test methods including the Isometer, the Filmeter, and electrical breakdown voltage tests for film thickness, $SO_2$—humidity tests for efficiency of sealing, acetic acid—salt spray test for corrosion resistance and Schuh and Kern abrasion tests. It is concluded that these test and instruments offer useful and reliable methods of acceptance testing but further work is needed to standardize the conditions of carrying out certain of the tests if they are to be used in specifications.

## Discussion

MR. V. F. HENLEY (W. Canning and Co. Ltd.) said that he was Chairman of the British Standards Institution Committee that dealt with standards for anodic oxidation and he would report the authors findings to the next B.S.I. meeting.

The authors had focused attention on two very important factors which contributed to the weather resistance of anodic coatings, namely the ability to resist chemical attack and the freedom or otherwise from macroporosity.

The sulphur-dioxide test, when used on anodic coatings, appeared to be a measure of the degree of solubility of the anodic coating in dilute sulphurous acid which in turn had probably a little sulphuric acid present.

As was the case with many chemical reactions, the amount of moisture present had considerable bearing on what happened. Illustrating this point, he said that the General Electric Company Research Laboratories were carrying out work on the service performance of anodized reflectors. In-

cluded in this programme were some reflectors which were exposed in a magnesium foundry on continuous production where the atmosphere was warm and comparatively dry but contained a high percentage of sulphur dioxide due to the use of sulphur during the melting process. The reflectors showed no attack whatsoever after several months, although so much sulphur dioxide was present.

In contradistinction to that, similar reflectors which were exposed in a steam railway tunnel near Euston, showed very bad attack in seven to fourteen days. Even films 0.001 in. thick, properly sealed, showed blooming, and at the end of a month the reflectors were almost unserviceable, even after cleaning. It seemed to him that the bloom which was experienced was purely the result of partial solution of the film ; in other words, a limited attack by sulphuric acid.

It was known and practised in this country that the use of a nickel acetate sealing solution as opposed to hot water increased the chemical resistance of anodic films. In other words, anodic films sealed in nickel acetate were more difficult to strip in either alkalis or acids, and he wondered whether the authors had had the opportunity of trying or were proposing to try the effect of this test on films which had been so sealed. He thought they would find even better resistance than they were getting with the hot-water sealing process.

## Testing Sealing Efficiency

The authors also suggested, quite rightly, that the test was a good method of testing the efficiency of sealing. The B.S. Specification No. 1615 had written into it a fairly simple sealing test, a test for the efficiency of sealing, based on the use of a dyestuff solution. This solution had been known for some years, and probably the most popular form was a solution of anthraquinone violet either in chloroform or some other suitable organic solvent or in water. He had carried out a number of tests with this type of reagent and it had always been possible to detect inadequate sealing in different conditions. It seemed to him that there should be some correlation between that type of spot test and the sulphur-dioxide or humidity cabinet results. Had Mr. Brace had an opportunity of checking the two methods, the point being that the spot test was a very rapid workshop method which would serve to deal with day-to-day production, and the cabinet would be a useful cross-check to make sure that the standard of production was being maintained.

The acetic-acid salt-spray test appeared to be one of the best contributions he had seen so far. It appeared to fulfil a long-felt need for an accelerated corrosion test that gave a relationship to behaviour in service.

Those who had been concerned with anodizing, particularly architects, for exposure to outside atmospheres had been worried about pitting that occurred on anodic coatings exposed to the weather, and if the accelerated test using acetic acid and salt proved as good as he thought it was going to be, the next issue of the B.S. Specification would be suitably improved.

## Need for Suitable Test

MR. C. E. MOORE (Ashton and Moore Ltd.) said that the inception of suitable tests for the user of anodic coatings was highly desirable. Anodizers were in rather an easier position than users, as it was not particularly difficult for an experienced anodizer to test his production from the point of view of either thickness or sealing.

Mr. Moore said that perhaps he was blessed by nature, because he had the sort of thumb which would always know whether a coating was suitably sealed or not ; he was not popular in the anodic shop as a result.

He agreed with Mr. Henley that there was a need for some alternative, a rather simpler alternative, as a test of sealing. He suggested something like a dye absorption test or other non-destructive test, if possible to be correlated with the results which had been given.

Much stress should, he thought, be laid not only on the thickness of film and sealing and the purity of the metal, but also on the metallography of the metal ; the pure metal in which the impurities, or the alloy in which the second phase, were distributed in fairly large pieces would not, as far as was known, give anything like the same results in corrosion resistance of the resulting film as one in which those other substances were more uniformly distributed.

There was, in fact, a marked phase, the body phase as it was called, in which it worked round the crystal boundaries and would cause the substance to fail under test, whereas in better distribution that would not occur.

MR. F. C. PORTER (Metallurgist, Aluminium Development Association) said that the work in the paper was largely occasioned by the developments in anodized aluminium in the motor-car field and in architectural finishes, particularly architectural finishes, where advantage was being taken for the first time of the ultimate mechanism of corrosion resistance which anodic films could offer. So many of the applications of anodic films in the past had only to a very limited extent taken advantage of the corrosion resistance ; and in domestic articles, such as tea trolleys, very indifferent qualities of anodizing still passed muster.

Mr. Henley did not do full justice to his post as

Chairman of the B.S. Committee when he referred to B.S. 1615. He had just been responsible for bringing out a revised edition of the original 1949 standard ; in the standard for the first time was now a group of coatings 0.001 in. thick.

In the paper by Brace and Pocock he was interested to see that corrosion tests using acetic acid salt-spray would show how the corrosion resistance of a film 26 microns thick took longer than 1380 hours to fail. On films of only half that thickness the life was only one-sixth as great. In fact, the corrosion rate went up rather more than the square of the film thickness. This put 0.001-in. coatings in a completely different category from most external films which were in existence, and he felt that architects and other potential users should be told that they were dealing with a material with completely different properties.

It was certainly useful to see that there were two different methods of approach for film-thickness and sealing tests and corrosion-resistance tests.

The Aluminium Development Association had drawn up for the guidance of architects an acceptance specification for weather resistance for finishes, and had concentrated on thickness and sealing and left out corrosion-resistance tests, It was felt that for 0.001-in. films there was too long a testing period at the moment, the Association would be grateful for further developments of the acetic-acid salt-spray test which would enable the testing period to be reduced.

## Importance of $SO_2$

DR. F. A. CHAMPION (Research, Laboratories British Aluminium Co., Ltd.) said that in his experience in really severe industrial atmosphere the two important components were first $SO_2$ and secondly chloride. He wondered whether the acetic-acid addition to salt-spray could always be reliable in reproducing industrial conditions.

He asked Mr. Brace for his views on the alternative environment of $SO_2$ plus chloride, as, for example, by the addition of chlorine to the $SO_2$ beaker test. There might be objection to that, but the test was limited in capacity. Colleagues of his presented a paper to the Symposium of the Society of Chemical Industry last year on the corrosion of metals on plating and showed that the same principles could be applied to testing facilities of much larger capacity, and he would appreciate Mr. Brace's views with respect to anodic films.

Hydrogen peroxide had been used for a very long time on accelerated laboratory corrosion tests on aluminium in general, and erroneous conclusions had been formed because of this acceleration. It did accelerate corrosion a good deal but other constituents could also affect considerably the stability of the hydrogen peroxide and so affect the degree of acceleration. That might not apply to the tests on anodic films where the purer metals were employed, but he would like to give a warning that there were limits to the use of acceleration.

## Capacitance Test

DR. T. P. HOAR (Lecturer, Metallurgy Cambridge University) said that he was interested to hear Mr. Moore's comments on the possibility of dyestuff testing of sealing.

Experiments were being carried out at Cambridge just now to investigate the mechanism of the sealing process and the general method being using was to measure the capacitance of the unsealed and the sealed panel and also the variation of the capacitance at different frequencies by applying alternating current during the sealing process.

The capacitance of the film fell after a time and a low value was obtained at high frequency. Presumably the usual kind of pore structure was present in the film with a barrier layer at the bottom, and this was being filled up in a not very well known way in the sealing process. In this type of commercial sealing there was a fall in capacitance.

If dyestuff tests were carried out for the same range, the adsorption of the dyestuff was nearly inhibited in this particular form of sealing process after sealing for about 60 seconds. The dyestuff did not distinguish between something that was practically unsealed and something that was probably well over-sealed.

It seemed to him that the only proper test was a much more pragmatic one of the kind Mr. Brace suggested—the $SO_2$ salt-spray test, or something of that kind.

## Iodide-Iodate Test

MR. R. WALL (Metallurgist, Associated Automation Ltd.) said that he would give a brief description of the test he used. In particular, his company had had considerable trouble with a duplicating machine which used an aluminium-alloy moistening roller. This machine used a commercial methylated spirit for the wetting agent, which was pumped from a canister made of tin plated brass. Within the pump there was a stainless-steel ball valve, phosphor-bronze spring and brass tube and a rubber flex. This took the fluid on to a spray which impregnated a felt pad in contact with the aluminium roller.

In use, due to dissolution of metal from all these containers, the metals were concentrated over a period of time in the felt pad. There was considerable pitting on the line of contact with the pad, particularly when the machine was left idle. The whole machine had been taken apart to test the quality of the anodic film, and at one

stage the use of another material had been considered.

Recorded in one of the Aluminium Development Association's handbooks was the potassium iodide-iodate test. Although the test had not been accepted, his company introduced it as a porosity and anodic production test, for use on the shop floor, the roller anodically and the aluminium cathodically, using a Whatman filter paper and a modified solution as described in the paper. The filter paper was soaked and put between the two, and six volts passed through it. Porosity showed at once as an iodine stain.

## Author's Reply

MR. A. W. BRACE, replying to the discussion, said Mr. Henley had made some interesting observations, although he was not able to agree with one of them. He pointed to the beneficial effects of nickel acetate in sealing. Mr. Brace had made tests with nickel-acetate-sealed panels, and although he had perhaps detected an improvement, the exposure testing (the improvement was detected in an accelerated test) had not shown a very marked superiority for the nickel-acetate-sealed panels. It was slightly better but not sufficient, and he would like to take a strong stand on that issue.

Sealing in potassium dichromate did markedly improve the corrosion resistance of anodic coatings, even in industrial atmospheres. This was not surprising in marine atmospheres, but there had been a definite improvement in industrial atmospheres. Unfortunately, there was the very, distinctive yellow colour which in many circumstances was objectionable.

A number of people had referred to spot tests particularly the use of dyestuffs and so on. On the whole, Mr. Brace's results tied more closely with those of Dr. Hoar and his colleague, although he had found that the period was very slightly longer than he had indicated. He would certainly say that in the first five minutes of sealing at boiling point the ability to absorb any dyestuff disappeared. As the temperature fell the effect became slightly more marked, but it was usually necessary to get below 80°C. before it became really marked and perceptible. His experience had been that the $SO_2$ humidity test was much more sensitive and discriminating in these respects, and he felt that from this point of view it was an advance.

The real point about sealing was that there was not any really sharp boundary between bad sealing and good sealing, *not* that there was a continued increase in resistance. He believed that sealing of the anodic coating involved converting it to böhmite. It had already been established by several workers that the higher the temperature formation in the böhmite the lower its solubility and in turn the better the corrosion resistance. His own experiments in that direction seemed to bear out those observations. Finger-print tests, dyestuff tests and so on were a useful workshop way of checking against really bad practice, but he thought that the $SO_2$ humidity test would prove to be even more discriminating.

Mr. Porter had referred to 0.001 in. films but Mr. Brace felt that it was very doubtful if it was practicable to have a test that would give an overall corrosion resistance assessment in a short time. It seemed to him that with a coating on which exposure experiments (not surprisingly, corrosion resistance) had been carried out, when the testing was speeded up to produce rapid breakdown, a number of other factors would be introduced which would tend to make it not a measure of true corrosion resistance but simply a form of measurement of chemical resistance under particularly severe and unusual conditions that had little relation to service life.

The corrosion resistance of an anodic coating was very much influenced by the anodizing conditions. It was hoped to publish later some work in this direction, but he would like to quote one or two of the results on D57S exposed in East London. It had been found for example, that if the alloy was anodized to a 10-micron film thickness and then exposed at 45°C without cleaning, definitely observable pitting was obtained in 14 months if anodizing was done in a 1.6 normal heavily acid electrolyte at 60°F. On the other hand, when the anodizing temperature was increased to 80°F a similar standard of pitting could occur in only three months. By use of a slightly stronger electrolyte, 3 normal, with the same film thickness, twelve months elapsed before this standard of pitting was reached with the electrolyte at 60°F and three months at 75°F. With factors of this kind the combination of film thickness and $SO_2$ testing might fail.

More work was being done on the acetic salt-spray test to see how well it helped to reveal the influence of factors such as this. There was certainly some indication that it did help, but he had not sufficient data at the moment on which to take any particular stand. The question was an important one, because he considered that the trend would be increasingly towards using weak sulphuric-acid electrolytes, higher anodizing voltages and probably relatively lower temperatures.

Dr. Champion raised an interesting point. He suggested that consideration might be given to a modification of the CRL beaker test by adding chlorine to it. This was an interesting and reasonable suggestion but from a commercial point of view a larger apparatus than the CRL beaker would be required for practical production tests

# FINISHING POST

A SELECTION OF READERS' VIEWS COMMENTS AND QUERIES ON METAL FINISHING SUBJECTS . . . . .

*Advice on all aspects of metal finishing practice is offered on these pages, and while every care is taken to ensure the accuracy of information supplied no responsibility can be accepted for any loss which may arise in respect of any errors or omissions.*

## Vitreous Enamelled "Blackboards"

Dear Sir,

I was interested to see a reference in the April issue of your Journal to a recent installation of vitreous enamelled metal chalkboards at the Wolverhampton Technical College.

Your readers may be interested to know that frits for producing such finishes have been manufactured by the writer's Company for a number of years. As a matter of fact, a contract for the supply of vitreous enamelled chalkboards was carried out by William Mallinson and Sons Ltd., of London, E.2 two years ago. This was to the Alconbury Dependent's School, R.A.F. Station, Alconbury, Huntingdonshire. This particular undertaking involved approximately 1,000 square feet. The enamelling of the steel was carried out by Stewart and Gray Ltd., using Escol frits.

The finish on this occasion was matt and the colour chrome green, and recent enquiries have proved that these chalkboards are continuing to give satisfactory service.

Yours faithfully,

J. H. GRAY.

Managing Director,
Escol Products Ltd.,
London, S.W.17.

## Refrigerator Flow-Coating Line

*Those of our readers who found the description published in last month's issue of the Refrigerator Finishing Line installed at the Dundee works of Astral Equipment Ltd. of interest, will be interested to learn that the suppliers of the paint to this line are Robt. Ingham Clark and Co., whose technicians maintained close liaison with the project throughout all stages of its development.*

## Metal Finishing Conference

(*Continued from page* 179)

One of the things that guided Mr. Brace in the tests was that he thought that it would be agreed that it it was possible to use a similar test to this on plating—and it was not unreasonable from theoretical and practical considerations—then it was advantageous. On the whole, he felt that the results had justified this. It was known that from the point of view of the industry it was a nuisance if it was necessary to use a separate piece of equipment for testing each type of finishing. He hoped that Dr. Champion would do more work in this connexton. But it seemed to him that unless there was a strong case against it platers would prefer to use similar tests to those they were already acquainted with and equipped for.

Dr. Hoar had plotted a capacitance curve. This was interesting because it proved to be the inverse of the weight increase curve. It would be interesting to compare the capacitances of böhmite films produced by direct reaction with the aluminium against what he considered was böhmite produced in an anodic coating. In particular, it would be interesting to see what happened with very thin films and by comparing films of similar thickness and characteristics.

There was some evidence that the continuation of the sealing time would slightly improve corrosion resistance, and commercial practice, he thought was to try to compromise between these effects. But the slope of the curve and the rate of rise were very dependent on the characteristics of the electrolyte. With a very strong heavily acid electrolyte like 20 per cent by volume at 75°F the curve obtained was not the same as that obtained with a relatively weak solution. The old rule that sealing time had to equal anodizing time tended to break down; he preferred at least 20 minutes for most purposes and with thicker coatings at least 30 minutes.

He thought that the potassium iodide/iodate method would show up really bad sealing but he thought that it was not as discriminating and he tended to rate it with the dyestuff test. Normally there should not be gross porosity in anodic coatings. The very nature of the mechanism of formation of anodic coatings should give freedom from porosity unless there were major material defects to contend with. But the problem was not in the processing but in the original material. There was a definite limitation on the value of the test because normally gross porosity of the type that could be detected by this test, given reasonable processing conditions, should not be experienced.

(*To be Concluded*)

# OCCA Exhibition . . .

This is the second and concluding section of an article describing some of the stands at the Oil and Colour Chemists' Association Exhibition held in the Royal Horticultural Society's New Hall, London, recently. The first section appeared in last month's issue of the Journal.

## A. Boake, Roberts and Co. Ltd.

*Carpenters Road, London, E.*15.

THIS exhibit showed the advances made during the past year in the use of "Abrac A," an oxidized vegetable oil, in the surface coatings industry. One important application is as an anti-corrosion additive, and the exhibit indicated how much can be used, both to improve and to lower the cost of anti-corrosive primers, and to give improved adhesion to metals.

A recent development which is proving of considerable interest is the use of this product in the manufacture of epoxy resin esters. Other applications on which information was available included the use of the material in the manufacture of improved drying oils, polyester resins, epoxy potting and casing resins and in alkyds.

## Kestner Evaporator and Engineering Co. Ltd.

5 *Grosvenor Gardens, London, S.W.*1.

THERE were three exhibits of interest to paint users on this stand. The Kestner patent hot coil immersion heating system is the latest of a series of developments in the direct firing of process vessels, and is designed to eliminate the difficulties caused by flame impingement and consequent degradation of the product. Only hot flue gases at a controlled temperature are used for the heating of the charge, and the system offers both rapid heating and cooling, together with good temperature control.

The design of the furnace system also permits the use of more than one process vessel on the same heating system, and it can be positioned, if necessary, in a completely separate area to meet flame proof requirements.

The hot coil immersion heating system utilizes an external furnace in which the gas or oil is burned, and the hot flue gases circulated through a generously-sized coil immersed in the fluid to be heated.

The external furnace is designed to permit ancillary air to be fed into the furnace as required to obtain the desired temperature in the outlet flue gases. This ancillary air is used to cool the furnace walls before being mixed with the hot flue gases, thus reducing the heat losses and thereby improving the efficiency of the system.

The temperature of the flue gases at the inlet can be controlled and adjusted to suit the process and thus overheating and degradation is eliminated. The high velocity of the flue gases and large surface area of the coil give a much improved heat transfer and as the gases leave at a temperature little above that of the charge being heated a high efficiency is obtained and fuel costs reduced.

The same multi-turn immersion coil is utilized when cooling is required, and it is arranged so that cold air may be drawn through the coil in place of the hot flue gases to cool the charge, thus eliminating the necessity for further apparatus for cooling. The air is drawn through the coil at high velocity giving a high heat transfer and consequently rapid cooling.

A typical installation has been designed for producing alkyd resins by the solvent process.

Also being exhibited were the Kestner isoductive heating system developed specifically for the paint and allied industries where it can be used for the electrical heating of vessels and pipelines, and the company's new portable flame-proof stirrer able to handle up to 2,000 gallons of liquid, depending upon the viscosity.

## Kek Ltd.

*Palmerston Street, Ancoats, Manchester.*

THE theme of the display on this stand was the use of fluid energy reduction jet mills for the continuous dry grinding of solids, ranging from heat sensitive soft waxes to hard abrasives, down to low micron particle sizes. The range of "Jet-o-mizer" mills represents a recent advance in this field, and the principal exhibit on the stand was the model 0202-2, the smallest mill of this type available. (*Fig.* 7)

The mills are manufactured by Kek Ltd. under exclusive licence from the Fluid Energy Processing and Equipment Co., U.S.A. Specifically, it is claimed that these improved fluid energy mills deliver micron and sub-micron products of much narrower distribution range than is obtainable with

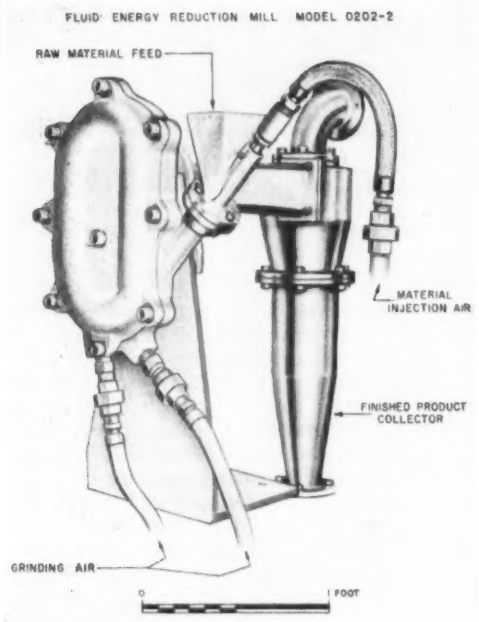



*Fig. 7.—A fluid energy reduction jet mill, These mills formed theme of the Kek stand.*

other types of grinding equipment, and they are being successfully used for reducing hard talcs, clays, ceramics, metals, pigments, resins and many chemicals. In addition, machines can achieve many other functions simultaneously with fine grinding, such as dehydration of wet materials, coating of fine particles with other materials and chemical reactions.

## Aero Research Ltd.

*Duxford, Cambridge.*

A DISPLAY of coated specimens on this stand illustrated the properties and applications of the "Araldite" range of epoxy resins for the surface coatings industry.

Consisting of a resin and a hardener, 820-RH is suitable for cold curing finishes or, alternatively, for finishes that cure rapidly at elevated temperatures. It is recommended where good chemical resistance allied to rapid drying is required. The coatings can be clear or pigmented and cure without blushing even at high relative humidity. They give excellent adhesion to metals, among other materials, and when cured do not become brittle on aging.

Already well-established in the surface coatings industry are 985E and 961D. The excellent combination of properties possessed by both these resins has made them popular as the basis of stoving finishes in many industries.

Lacquers based on 981-AB have a relatively wide stoving range, i.e., 3 to 15 minutes at 240°C or 40 to 80 minutes at 180°C. The main advantage of employing finishes tolerant to a certain latitude in curing conditions is where continuously-operating ovens which can work at higher temperatures are in use. These coatings are very well suited to the internal protection of metal containers etc.

Supplied as two viscous, solvent-free solutions, 880-AB can be used in the preparation of clear or pigmented stoppers able to cure in a short time with negligible shrinkage, and adhesion to most metals is so good that priming is unnecessary. Thick films can be applied in one operation.

The 6000 series provides a range of four basic, solid epoxy resins for paint manufacturers who may wish to formulate their own epoxy finishes.

Two of these resins are available in solution form and are known as 6100/70 and 6300/50.

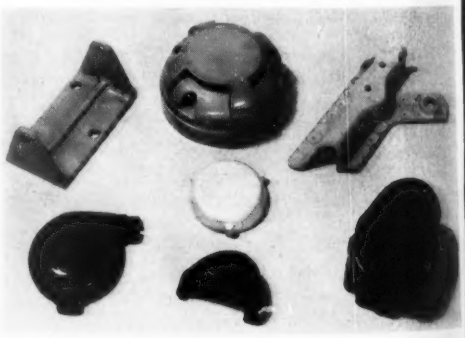
## Laporte Titanium Ltd.

*Hanover House, 14 Hanover Square, London, W.1.*

VARIOUS exhibits by this company drew attention to the range of organic titanium compounds which they now have in production or under development. Particular emphasis was placed on the use of tetra normal butyl titanate and polymeric butyl titanate in he atand corrosion resistant paints.

One unit demonstrated that paints formulated on polymeric butyl titanate with aluminium powder as the pigment, are able to give protection to steel at over 500°C. Another exhibit in which a steel tube was maintained at 400°C and subjected to intermittent water spray illustrated the heat and corrosion resistance to a paint based on polmeric butyl titanate pigmented with zinc dust and aluminium powder.

*Fig. 8.—A display of specimens coated with epoxy resins (Aero Research).*



# FINISHING NEWS REVIEW

## SCANDINAVIAN ENAMELLERS MEET IN SWEDEN

### *Institute may be Formed at Conference*

THE conference of the Scandinavian vitreous enamellers is to be held at the Stora Hotel, Jornkoping, Sweden, from May 19-20 next. It is being arranged by Huskvarna Vapen Fabrik A/B, and it is expected that about 100 visitors will be in attendance.

Some time has been allotted at the conference to a discussion on the formation of a Scandinavian Vitreous Enamelling Institute. The technical sessions are as follows :

(1) " Practical experience in the enamelling of cast iron ", by Mr. O. Schroeder, Denmark. (2) " Quality Control of Enamelware ", by Mr. H. Carlsson, Sweden. (3) " The influence of vitreous enamels' physical and chemical qualities on high class enamelware ", by Mr. R. Marker, Sweden. (4) " Industrial design of enamelware from an artistic and production point of view ", by Mr. G. Gahmberg, Finland.

On both days there will be visits to works in Sweden.

## TRADE MISSION TO CANADA

AN all-in tour of Canada by a British Dollar Exports Council delegation, led by Sir William Rootes, began at the end of last month. Others in the party included Sir Vincent Tewson, general secretary of the Trades Union Congress, Lord Riverdale, Sir Edward Herbert, Sir Norman Kipping and Sir Charles Hambro.

The visit of this delegation from the United Kingdom follows the successful visit to Britain at the end of last year of the Canadian Trade Mission led by Mr. Gordon Churchill.

The delegation will be promoting further measures for the development of Anglo-Canadian trade and will hold discussions with the federal and provincial governments, the United Kingdom High Commissioner and trade commissioners, and the Dollar Sterling Trade Council.

Arrangements for the tour in Canada have been made by the Dollar Sterling Trade Council, in conjuction with the Canadian Association of British Manufacturers and Agencies.

## PHOSPHATING PROCESSES SPECIFICATION

THE phosphating processes known as Atram A. B, C, F55, and O.S., marketed by Roto-Finish Ltd., Hemel Hempstead, Herts., have been tested by the Ministry of Supply inspectorate of armaments in accordance with inter-Services defence specification DEF-29, and also to long term tests in salt spray testing apparatus (cabinet) conditions, as distinct from the salt droplets spray test of this specification. All the tests were satisfactory.

## TOOLMAKER'S EXPANSION

An additional factory—their fifth—has been acquired in the Slough Trading Estate by Wolf Electric Tools Ltd., London.

The new premises will make available an extra 15,350 sq. ft. of floor space and are to be used for promoting planned developments.

## OUTPUT REDUCED

SECOND cutback in nickel production this year (by 10 per cent to 250-million lb. annually) was announced last month by the International Nickel Co. of Canada Ltd. The move had been anticipated earlier.

## I. OF M. AWARDS FOR 1958 TO PROF. HUTTON, DR. HOLLOMON

THE council of the Institute of Metals has made the following awards of medals for 1958 :

*The Institute of Metals Medal in Platinum* to Professor Emeritus Robert Salmon Hutton, M.A., D.Sc., in recognition of his outstanding work in connection with the science and practice of non-ferrous metallurgy.

*The Rosenhain Medal* to Dr. John Herbert Hollomon, in recognition of his outstanding contributions to knowledge in the field of physical metallurgy.

Shortly after World War 1, Professor Hutton proposed to the Industrial Fatigue Board the study of metal-polishing processes and collaborated with the Board's investigators in a research comprising motion study, vocational selection, and training workers at machine metal polishing. The results of this study were published by the Medical Research Council.

In 1921 he was appointed first director of the British Non-Ferrous Metals Research Association. Until 1930 all research work was carried out extra-murally. Nevertheless more than 40 researches were carried out by individual investigators, and one of the most important outcomes of this work was the development, in 1927, of aluminium brass condenser tubes.

He returned to academic life when, in 1932, he was appointed first Goldsmiths' Professor of Metallurgy in the University of Cambridge. Here he supervised an extensive investigation for the Goldsmiths' Company into the tarnishing of silver and the possibilities of preventing it.

He was, from 1945 to 1952, temporary director of research and later a member of the governing council of the design and research centre for the gold, silver and jewellery industries.

Dr. John Herbert Hollomon is manager of the Metallurgy and Ceramics Research Department of the General Electric Research Laboratory, Schenectady, New York.

His professional honours include the Rossiter W. Raymond award of the American Institute of Mechanical Engineers in 1946, and the Alfred Noble award of the Combined Engineering Societies, 1947, for a paper entitled " The Mechanical Equation of State ". In September 1951, he was one of five U.S. physicists elected as participants in the Ninth International SolvayPhysics Conference on solid-state physics at Brussels.

## INDIA MAKES AIRCRAFT FINISHES

FOLLOWING the visit to India last year of the technical director of Cellon Ltd., Kingston-on-Thames, Surrey, arrangements have been made for the firm's aircraft finishes to be manufactured there by Macfarlane and Co. Ltd., Bombay.

One of Macfarlane's chemists, Mr. Banerji, has been working at the Kingston laboratories for the past three months with Cellon's chief chemist, Mr. Ledwith. He left recently to return to India.

## CHANGE OF ADDRESS

MIDLANDS office of Barlow Whitney Ltd. has been moved to 44, Queen's College Chambers, Paradise Street, Birmingham, 1., Telephone : Midland 6897.

# Canadian Trade Mission Report

## *Finishing Industry Could Play Major Part*

THE report of the Canadian Trade Mission that visited Britain in the second half of last year was published recently in Canada. It will be obtainable in Britain from the Dollar Exports Council, and a copy is to be sent to each of the 1,600 firms who were visited by, or expressed an interest in, the delegation. In the metal finishing field, some of the companies visited were Baker-Perkins Ltd., of Peterborough, Imperial Chemical Industries Ltd., London, and Metropolitan-Vickers Electrical Co. Ltd., Manchester.

Included in the report is a section dealing with the factors affecting British trade in Canada, and the Mission's recommendations on these. In the main, they are a restatement of the points the mission made on arrival in Britain, at a press conference in the Board of Trade, when they spoke about the importance of British firms pursuing an active and aggresive selling policy in Canada.

Main competitor of the U.K. in selling to Canada, of course, is the United States, and the Mission says about this " . . the border is no bulwark against the flow of newspapers, trade and technical publications, magazines and films from the United States . . . over 500 million pieces of American advertising come into Canada every year (apart from radio and TV advertising). "

" Canadians generally prefer American styling, packaging, presentation, engineering, design and choice of fabric ", the report goes on to say, although there is a wide market for products of traditional British craftsmanship.

There is a recommendation that Canadian engineers, who tend to think in terms of U.S. engineering standards, should consult " the excellent trade and technical publications " which the Mission had been able to study in Britain, to make themselves more familiar with British engineering.

The Mission thinks that the British exporter should allow three to five years for establishment in the Canadian market during which time " returns may not be particularly encouraging ". And U.K. manufacturers wishing to start up Canadian subsidiaries should consider associating with an existing local firm. The best way to advertize, the report suggests, is to launch a co-ordinated public relations programme to tell Canadians of U.K. export successes and of British scientific achievements.

### LORD MAYOR VISITS BIRMINGHAM WORKS

THE Lord Mayor of Birmingham, Alderman John J. Grogan, M.B.E., J.P., accompanied by the Lady Mayoress, paid an official visit recently to the works of W. Canning and Co. Ltd.

With the Lord Mayor on the tour of the works was Sir Ernest Canning, and the picture below shows the two with Mr. E. R. Reckless during the visit to the engineering division's premises. Alderman Grogan took the opportunity to speak to many of the employees during his comprehensive inspection.

## INSIDE VIEW

THIRTY-ONE boys drawn from public schools throughout the country spent five days recently seeing the gas industry from the inside.

They were welcomed in Derby last month by Mr. R. S. Johnson, chairman of the East Midlands Gas Board. During the following days the boys saw gas works, research laboratories, grid control centres, offices and showrooms in the Midlands, South West, and Wales, part of Britains' £400 million gas industry.

This was the second short works course arranged by the Gas Council in collaboration with gas boards and the Public Schools Appointments Bureau to stimulate interest amongst boys who are about to choose a career and to show them something of the wide variety of opportunities and careers which exist within the industry.

# U.S. ELECTROPLATERS CONVENTION

## Meeting next year will be Golden Jubilee

THE golden jubilee convention of the American Electroplaters' Society will be held in Detroit, Michigan, U.S.A., from June 14 to 19, next year. The Society will act as hosts to the participants in the fifth international conference on electrodeposition and metal finishing. The conference will cover a five-day period, and is planned to include at least thirty papers by well-known authorities from various countries.

A metal finishing exposition will form another important part of the convention, and here there will be a display and demonstrations of the most modern equipment, processes, and materials in use in the industry. More than 175 companies are expected to participate in the exposition.

The convention will provide an opportunity for guests to visit certain important manufacturing plants in the Detroit area, centre of the metal finishing industry in the United States.

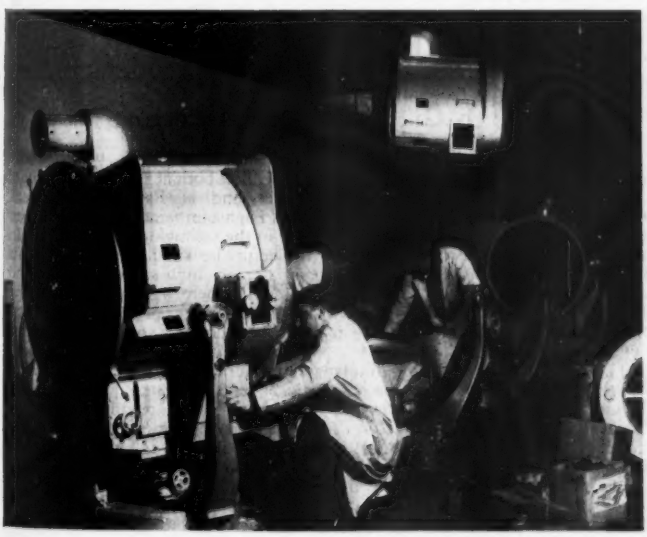
Many members of the American Society attended the third and fourth international conferences held in London, and are hoping to be able to return the hospitality that was extended to them on these occasions.

### FLOODLIGHTS FOR NIAGARA FALLS

BELOW is the scene in the assembly shop at Savage and Parson's Watford factory as the first of 20 floodlights the firm is making for the illumination of Niagara Falls is built up. Each of the lights has an output of 210 million beam candlepower, weighs 18 cwt., and costs about £1,400. The shields to ward off flying ice and spray, and the light on top of the lamphouse which gives a red warning signal within 15 minutes of carbon exhaustion, can be clearly seen.

Savage and Parsons were awarded the contract by the Canadian subsidiary of the General Electric Co., U.S.A., in the face of fierce transatlantic competition. The firm has long experience with this type of equipment.

Main hazard of equipment installed at the Falls is the penetrating spray that can cause heavy corrosion unless adequate precautions are taken. As a final protection for the floodlight casings, two coats of priming paint based on calcium plumbate has been used on all ferrous surfaces.



## OBITUARY

**Walters :** Mr. William Walters, who was sixty-eight, died suddenly last month while on holiday at Weston-Super-Mare. A director of B. J. Round and Sons Ltd., Northampton Street, Birmingham, 18, he had taken an active part in the business up to the time of his death.

Starting with the firm as an errand boy in 1903, Mr. Walters had worked with four generations of the Round family, eventually becoming works manager and later joining the board of the company. Mr. Walters was a well-known figure in the trade and will be missed by his many friends, as well as by his associates in the firm.

**Pawley :** The death occurred recently, at the age of 78, of Mr. John Hampton Pawley, a director of George Cohen Sons and Co. Ltd., whom he joined 51 years ago. Up until last December, Mr. Pawley, was in personal control of the firm's dismantling activities — involving every year the negotiation, and general supervision, of hundreds of major contracts.

## THIS COULD HELP

TAKING your car abroad soon ? If you are, Trico-Folberth Ltd., Great West Road, Brentford, Mddx. have got just the thing for you, and its free on application.

It will save you a lot of trouble, and could save you a few francs (or marks), especially if your mental processes when conversing on the other side of the Channel tend to slow down a little.

The aid is a double-sided printed card designed to clip to a car's sunvisor. The card carries conversion charts of miles to kilos, gallons to litres, etc., and Continental pertol prices are expressed in Sterling. Lots of other information is contained such as a lightning calculator that shows at a glance the value of any of eight different currencies up to the equivalent of £5. And in case you get lost, there is a simple chart that allows you to use your car radio to identify local transmitters.

## Review of Industrial Diseases

A REPORT by the Industrial Injuries Advisory Council reviewing the list of occupational diseases for which insurance is provided under the Industrial Injuries Acts in respect of specified occupations, was published recently (Cmnd.416, H.M.S.O. 1s. 9d.) Its recommendations have been accepted by the Minister of Pensions and National Insurance, Mr. John Boyd-Carpenter.

The Council recommend changes for 22 out of the 40 diseases under review and suggest an inquiry into the incidence of elbow conditions in trades involving manual labour. The number of insured persons affected by the proposed changes in the cover for diseases is expected to be very small. It is proposed that the description of poisonings by some substances e.g. lead, benzene, should be extended to certain of their compounds. Changes are also recommended in the definition of industrial dermatitis and radiation injuries.

The Industrial Injuries Advisory Council is a body set up under Section 61 of the National Insurance (Industrial Injuries) Act, to which the Minister can refer questions relating to the Act for consideration and advice. The chairman is Professor Sir Arnold Plant, who is Sir Ernest Cassel Professor of Commerce in the University of London.

## CENTRAL ADMINISTRATION

A FURTHER step in the co-ordination of the activities of their subsidiary companies (Thos. Goldsworthy and Sons Ltd., Manchester ; Helvetia Abrasives Co. Ltd., Leicester ; and London Abrasives Ltd., Tottenham) was announced recently by the establishment of a central administrative office for the group at the Marsh Lane, Tottenham, London, address. Staff changes arising from the move are reported in page 188. All correspondence for the entire group should now be sent to the English Abrasives Corporation Ltd. at Tottenham.

**SECOND INSTRUMENTS AND ELECTRONICS EXHIBITION**

SIR David Eccles, President of the Board of Trade, watches slave manipulators designed for use in atomic plants being operated at the second Instruments, Electronics and Automation exhibition which he officially opened last month. On the left is Mr. E.W. Semmens, chairman of the exhibition committee.

Of the 250 British firms that took part, more than a quarter were new exhibitors. In the international section, there were over a 100 leading manufacturers from Europe and the United States, and this was believed to be the first opportunity that British and overseas manufacturers of the electronics and instrument industries have had of exhibiting side by side under one roof.

Sponsored by six of the leading trade associations, the exhibition covered all aspects of the industries. At a six-day conference held simultaneously, leading figures from British Industry spoke about the applications of instrumentation in modern processing. There was also a " popular " evening lecture, when Freddie Grisewood, presiding over a panel that included representatives of scientific and technical education and of industry took the chair and invited questions about science as a career. The audience comprised both ambitious youngsters wondering what the profession offered, and industrialists keen to learn how to give the maximum opportunity to their young and promising employees.

## Sixth Gillett Memorial Lecture

Dr. Clyde Williams, former president of the Battelle Memorial Institute and now president of Clyde Williams and Co. (industrial research and management) will present the 6th Gillett memorial lecture at the 61st annual meeting of the American Society for Testing Materials to be held at the Hotel Statler, Boston, Mass., U.S.A. on June 24.

The lecture, sponsored jointly by the A.S.T.M. and the Battelle Memorial Institute, commemorates Horace W. Gillett, first director of Battelle and one of the U.S.A's. leading metallurgists. Each year it covers a subject pertaining to the development, testing, evaluation, and application of metals.

Dr. Williams, who worked with Dr. Gillett both at the U.S. Bureau of Mines and at Battelle will speak on " High-temperature metals—their role in the technological future ". In his lecture he will discuss the materials for use in high-speed aircraft and missiles, where aerodynamic heating and the nature of the propulsion systems create special problems. These materials include cobalt, columbium, chromium, molybdenum, nickel and tungsten, and demand for them could readily double or triple by 1965, says the Society.

Dr. Williams is a member of numerous technical societies here and abroad and is the author or co-author of over 100 journal contributions and bulletins on a variety of subjects.

# Annual Tin Conference

## *Developments in Tinning Discussed in Paris*

The possibilities of mechanizing the process of hot-tinning and a new method of tinning cast-iron were outlined to French metallurgists and chemical engineers at the Seventh Annual Tin Conference organized recently by the Centre d'Information de l'Etain in Paris. The conference was principally devoted to practical techniques of hot-tinning.

In an introductory review of the subject, Dr. W. E. Hoare, assistant director of the Tin Research Institute, Greenford, Middlesex, underlined the effectiveness of the old-established technique of hot-tinning and the possibilities of fitting the process into the technique of modern industry. Although hot-tinning had its origins as a craft, Dr. Hoare reminded his listeners, "there have been useful advances both in the bases of the technique and in methods of operation."

**Mechanization under-rated**

"At the present time the tendency is more to underrate the possibilities of mechanization than to underrate the necessity for manual skill", contended Dr. Hoare, who went on to describe how, in recent years, the laboratory technologist and the practical operator have come together to evolve design and layout of plant suitable for a variety of work, yet capable of some degree of mechanization.

**Hot-tinning cast iron**

A colleague of Dr. Hoare, Mr. C. J. Thwaites, assistant chief metallurgist at the Tin Research Institute, described a new method of hot-tinning cast-iron, the direct chloride process, recently evolved in the laboratories of the Institute.

Mr. Thwaites emphasized that this new process called for no special equipment and could be operated with the normal equipment available in a hot-tinning workshop. The preparation before tinning requires carefully controlled blasting with fine steel grit and dipping in a flux solution, not dissimilar from the flux used in ordinary tinning processes.

**Mechanization of hot-tinning**

A film on hot-tinning, made at the laboratories of the Tin Research Institute, was shown, and other speakers at the conference, which was under the presidency of Monsieur A. de Buyer, president of the Syndicat National des Fabricants d' Articles Galvanises et Etamés, were M. J. Mantelet, who dealt with the mechanization of hot-tinning identical massed-produced articles, and M. L. Mesager, who described the mechanized hot-tinning of a variety of different articles.

## *DEMONSTRATION WEEK IN MIDLANDS*

MANUFACTURERS and suppliers of barrel finishing equipment, material and processes, Roto-Finish Ltd., Mark Road, Hemel Hempstead, Herts., have been running a special demonstration week at The Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2., from May 12 to 16.

Several of their machines were exhibited as well as processes for descaling, deburring, radiusing, brighthoning, colouring, etc.

### SIR GEORGE EARLE TROPHY FOR I.C.I.

SEEN below is the Sir George Earle Trophy, awarded annually by the Royal Society for the Prevention of Accidents, to promote and acknowledge outstanding contributions made to industrial accident prevention.

This year, the award goes to Imperial Chemical Industries Ltd. "in recognition of the far-sighted policy of its board, and its attitude towards the problems of industrial accident prevention, and of the altruistic and generous way in which the extensive safety knowledge accumulated within its own organization has been made available continuously to industry throughout the world".

So far, the trophy has been awarded three times. First winners were, in 1956 H.M. Inspectors of Factories, and last year the award went to the Birmingham and District Industrial Safety Group.

The trophy is in two parts, the handsome silver Georgian inkstand pictured below, retained by the recipient for a year, and a commemorative plaque which is kept permanently as a record of the achievement.

The presentation was made by the president of the R.S.P.A., Sir Howard Roberts, C.B.E., D.L., J.P., at the Society's conference held from May 9-11 this year at Scarborough.

Sir George Earle, who put up the trophy, is chairman of the Associated Portland Cement Manufacturers Ltd. Inside the inkstand is a vellum roll on which the names of the holders of the award are recorded. Although the trophy cannot be presented to individuals, any firm can apply to the Society to be considered for the award.

# TECHNICAL *and* INDUSTRIAL APPOINTMENTS

Sir John Woods, G.C.B., M.V.O., a director of the English Electric Co. Ltd., has, owing to pressure of other work, resigned as chairman of the **Board of Trade's** advisory committee on the revolving fund for industry. Sir John has been chairman since the committee was appointed in July, 1953. The President has appointed Colonel E. R. Mayer, T.D., D.L., to succeed him. Colonel Mayer is managing director of Metlex Industries Ltd., and a member of the executive council of the National Union of Manufacturers. He has been a member of the advisory committee since its inception.

The President of the Board of Trade has appointed Mr. Gordon Grant, C.B., an under secretary of the Board, to be comptroller-general of patents, designs and trade marks, in succession to Mr. J. L. Girling who has retired.

* * *

Mr. George Boex, a former managing director of the **British Aluminium and Associated Cos.** retired from the board early this month. Advancing years have made him decide not to seek re-election, but he will continue in a consultative capacity.

* * *

Mr. G. S. Andrews, chief buyer at **Ransomes Sims and Jefferies Ltd.,** Ipswich, retired recently after 55 years service with the company.

*Mr. G. S. Andrews*

Well known in buying circles in the steel and allied trades he has been chief buyer at Ransomes since 1924.

Works director, Mr. H. H. Dawson, presented Mr. Andrews with a cheque on behalf of the directors and his collegues. Mr. Andrews has been succeeded by Mr. Peter Dorling, late of B. Elliott and Co. Ltd., Willesden.

*Mr. S. E. Clotworthy*

At the annual general meeting of the **Aluminium Development Association** held recently at 33, Grosvenor Street, London, W.1. Mr. S. E. Clotworthy was elected president of the Association for 1958/9. Dr. Maurice Cook (Chairman, I.C.I. Metals Division) was elected vice-president.

Mr. Clotworthy, is managing director of Northern Aluminium Co. Ltd., with whom he has been for more than 30 years. From 1942 to 1946 he was general operating superintendent of the company, largely responsible for the establishment of Rogerstone Works. In 1946 he became a director and general sales manager of the company ; he was appointed managing director in April, 1957. Mr. Clotworthy is a member of the Institution of Electrical Engineers and of the Institute of Metals, and is an Associate Fellow of the Royal Aeronautical Society.

The new chairman of the executive committee is Dr. N. P. Inglis (Research director, I.C.I. Metals Division in succession to Mr. J. H. Mayes.

* * *

Dr. P. H. Sykes, a director of the British Oxygen Co. Ltd., has been elected chairman of the Low Temperature Group of the **Physical Society.** The group was formed in 1946.

Mr. James F. McCartney has been appointed assistant to Ernest M. Hommel, president of the **O. Hommel Co., U.S.A.,**

Mr. McCartney has a broad background in selling, and will aid in promoting and expanding the company's activities in all phases of the ceramic industry. He will work closely with Hommel's sales and service representatives throughout the United States, particularlary with the frit division.

Before joining Hommel, Mr. McCartney was vice-president and general sales manager of Duff-Norton Co., a position he held for seven years, and, before that, was a sales representative for the Pressed Steel Car Co.

* * *

Three special directors have been appointed by the **English Abrasives Corpn. Ltd.,** following the consolidation of the group's administrative offices in London (News, page 186). They are : Mr. H. L. Steer, a director of Helvetia Abrasives Co. Ltd., who will be responsible for home sales activities ; Mr. V. L. Stevens, a director of London Abrasives Ltd., who will be responsible for export sales ; and Mr. H. Gaunt, secretary of the corporation.

* * *

Mr. J. W. G. Robards has joined **Cellon Ltd.,** Kingston-on-Thames, Surrey, as sales representative for the Black Country and North Staffordshire.

* * *

At the annual general meeting of the Corrosion Group of the Society of Chemical Industry held recently, the officers and committee for the session 1958/9 were announced.

Mr. T. H. Turner retires from the position of vice-chairman but will continue to serve on the committee ; he is succeeded by Mr. L. Kenworthy. A ballot of members had resulted in the election of Dr. F. Wormwell and Dr. C. Edeleanu to fill two vacancies on the committee caused by the retirements of Dr. J. C. Hudson and Mr. J. F. Kayser. The remainder of the officers and committee remain unchanged. They are ; **President**—Dr. S. G. Clarke ; **Hon. Treasurer**—Mr. W. E. Ballard ; **Hon. Recorder**—Dr. E. C. Potter ; **Hon. Secretary**—Mr. S. C. Britton. Education panel chairman is Dr. T. P. Hoar, and the education secretary is Mr. L. W. Stubbs.

# Chromite Production in South Africa

## *Barclay's Review Ore Output in Union*

IN an article on chrome ore in South Africa, the current issue of Barclays Bank D.C.O.'s " Overseas Review " says that the chromite deposits there are probably the most extensive in the world.

Although the occurrence of chrome ore in the Union has been known for many years previously, actual production of chromite commenced only in 1921 when a total of 1,188 tons was produced in the Transvaal at an estimated overall value of £400.

Regular production commenced in 1924 with an output of 5,040 tons for that year. Production subsequently expanded rapidly and in 1938 the annual output had reached 195,000 tons. Ten years later, by the close of 1947, this figure had more than doubled, to bring total production to no less than 411,000 tons. Of this total 327,000 tons were exported (the f.o.b. value being £757,000) 284,000 tons going to the United States.

The Review says that in 1956 output was up to 691,000 tons, and in the first nine months of 1957—the latest period for which figures are available—exports of chrome ore to the United States totalled 399,000 tons, with an f.o.b. value of £1,930,000. There are approximately 22 producers.

**Second Largest Producer.**

The article adds that if the important but unknown production figures of the U.S.S.R. are excluded, South Africa today ranks second only to Turkey amongst the largest producers of chrome ore. The chromite deposits in the Transvaal are probably the most extensive in the world.

The ore occurs in two main areas of the Union: the Eastern, (Lydenburg) belt, where numerous parallel seams have been traced intermittently over a distance of some 55 miles; and the Western (Rustenburg) belt, where numerous beds extend westerly and north-westwards for a distance of some 70 miles. Deposits are also known to exist in Natal and Zululand.

**Medium Grade Ore.**

South African chrome ore is of medium grade, containing 44 to 48 per cent. chrome, but can be concentrated to give higher grades. The available reserves of chrome ore, irrespective of grade, have been unofficially and conservatively estimated at two hundred million tons, adds the Bank.

# FILM ON CALCIUM PLUMBATE

CALCIUM plumbate constitutes an important addition to the few existing rust-inhibitive pigments for the protection of iron and steel.

Like red lead, it provides protection by a combination of basic and oxidizing characteristics, as well as film-forming properties by interaction with linseed oil.

It is believed to passify both cathodic and anodic areas on iron and steel, and in this respect differs from other rust-inhibitive pigments. In practice, it shows the behaviour which on theoretical grounds might be expected to be associated with this type of inhibition.

Linseed oil paints based on calcium plumbate have been found to be free from any tendency to crack, and their adhesion on galvanized iron and timber suggests the value of such paints as primers with a wide variety of applications.

A colour film has now been made by Associated Lead Manufacturers Ltd., the makers of Rustodian, a rust-inhibiting calcium plumbate paint.

The film shows some of the exposure tests to which Rustodian was subjected. The Shetlands were chosen for the tests because the salt-laden atmosphere there is amongst the most corrosive in the British Isles.

A flashback is made to 1941 — and the discovery of the rust-inhibiting properties of calcium plumbate. The initial experiments are reconstructed and the encouraging results which these produced are shown. Further tests made by researchers developing the pigment and the paint are described.

An animated diagrammatic sequence is used to explain in simple terms the theory of the electrical origins of corrosion. The film shows how a calcium plumbate pigmented paint inhibits rust and how it forms a protective layer over the cathodic as well as the anodic areas which exist in any piece of steel.

In 16 MM. Eastmancolour, the running time of the film is 22 minutes.

Copies can be obtained on application to the company at Clements House, 14, Gresham Street, London, E.C.4.

## MEETINGS OF THE MONTH

May 16

**Oil and Colour Chemists' Association (Midlands Section).** Works visit to Prices, Bromborough.

May 22

**Institute of Sewage Purification (Midland Branch).** Visit to Oxford Sewage Works.

June 24—26

**Institution of Chemical Engineers.** Symposium on the organization of chemical engineering projects, Olympia, London, W.14.

## EXHIBITIONS

May 12—21

**Production Exhibition and Conference.** Grand Hall, Olympia, London, W.14

**Gauge and Tool Exhibition.** National Hall, Olympia, London, W.14.

## NEW COMPANIES

*" Ltd " is understood, also " Private Co." Figures = Capital, Names = Directors, all unless otherwise indicated.*

**Dominion Spray,** 92, New Cavendish Street, London, W.1. March 12. £1,000. To carry on bus. of paint sprayers and enamellers, etc. Sidney J. Dutch and Mary E. Dutch.

**Willbro Paints,** 19/21 Herne Place, London, S.E.24. March 19. £100. To carry on bus. of distributors and manufacturers of and dealers in paints, etc. Rowland B. Williams and George I Williams.

**Isleworth Polishing and Plating,** rear of 273 High Street, Brentford, Mddx. March 28. £2,000. Herbert G. Arnold and Olive D. M. Arnold.

**Trade Finishes,** 54 Thornhill Road, Llanishen, Glam. March 28. £100. To carry on bus. of manufacturers of and dealers in paints and surface coating materials, etc. John Burchill and Mrs. Dorothy W. Burchill.

*From the Register compiled by Jordan & Sons Ltd, 16, Chancery Lane, London, W.C.2*

# TRADE and TECHNICAL PUBLICATIONS

A Birmingham firm of plant engineers, A. E. Griffiths (Smethwick) Ltd., Booth Street, Handsworth, have recently issued a brochure describing the various types of ovens they manufacture for all drying and finishing operations. The company is prepared to forward copies on request of executives.

The brochure is a well illustrated production, setting out three types of industrial ovens :—natural convection, forced convection, and radiation, with a short description of each type.

The equipment is described under three main headings, and these are gas and electrically heated equipment and automatic plants.

A separate section describes industrial stoving and drying equipment.

* * *

The **" Cerrux "** range of finishes made by Cellon Ltd., Kingston-on-Thames, Surrey, has been specially developed for use with the airless spray system, a comparatively new method of spray finishing.

The company have recently issued a booklet to describe the range, available free on application.

With an airless spray, the atomisation of the sprayed material reaches a high peak of efficiency. Using the technique, the temperature of the paint is raised above the boiling point of the faster solvents, but because the system is pressurised up to 50 atmospheres, these solvents are prevented from actually boiling. On operating the trigger of the spray gun, the release of paint is accompanied by an immediate vaporisation and substantial expansion of the solvent, resulting in a high degree of atomisation that is increased by air resistance.

The result is a deposition of finely atomised hot paint that is almost solvent free, but the paint formulation must be correctly balanced so that sufficient slower solvent is retained to ensure good flow during the process of drying. The " Cerrux " range has been developed to provide this balance.

The booklet begins with a brief mechanical description of the plant used with the airless spray system, and goes on to describe its advantages in industrial applications.

A recent addition of **" Lead,"** Vol. 21, No. 4, published by the Lead Industries Association, 60 East 42nd Street, New York, U.S.A., contains a number of articles on the use of lead and its derivatives in various building projects carried out in the United States.

Leaded porcelain enamels on aluminium have been used as curtain walls and panels on many of the country's " skyscrapers " in recent years and were used for the first time recently to provide the ceiling of the new Hampton Roads tunnel, designed to carry vehicular traffic beneath the sea to link two land promontories.

Twenty-three and a half miles long, the tunnel is the longest in the world built by the trench-type method of construction. More than 14,000 leaded porcelain enamelled extruded aluminium panels, 12ft. 9in. long by 1ft. wide were used for the ceiling.

The tunnel itself is made up of 23 prefabricated steel tubes, each 37ft. in dia., 300 ft. long, and weighing 12,000 tons.

Further articles describe among other things the use of lead as a membrane in an acid-brick lined oxidation autoclave in the Calera Mining Co.'s cobalt refinery.

Copies of " Lead " can be obtained free of charge on application.

* * *

A set of data sheets on the **Efco-Udylite** bright nickel solutions manufactured by the Electro-Chemical Engineering Co. Ltd., Sheerwater, Woking, Surrey, have been prepared recently by the company.

Comprising 27 sheets prepared for insertion in a loose leaf folder, the data includes information on solution compositions and operating conditions, rates of deposition, preparation and purification of the solution, conversion of existing Efco-Udylite solutions, analytical methods of checking the solution content, etc. The information concerns the use of the bright nickel plating process No. 66.

* * *

THREE new publications issued by **Keith Blackman, Ltd.** in recent weeks relate to " Tornado " axial, propeller, and centrifugal fans, and each provides full details of the relevant fan range, which includes specification, capacity tables dimension drawings, fan laws and other data applicable to the particular fan type, such as starters and regulators, etc.

Copies of the publications are available on application to the company's publicity department.

New ways to protect tanks in tankers, passenger ships and freighters is described in two booklets recently issued by Technische Voorlichtings Dienst, H. Vettewinkel and Zonen nv., Amsterdam, Holland. The booklets are in English and describe the **" Colturiet G.P."** coatings made by the firm.

The company says that the coating is a so-called cold-curing paint, its most important properties being the very great chemical resistance and exceptional adhesion on steel and other metals.

One of the booklets is made up of correspondence that has passed between the firm and various interested parties, including ship owners and Lloyd's Register of Shipping.

The second booklet describes the application of the coating and directions for its use. Copies can be obtained upon application.

* * *

A paint-bonding process, **" Fasbond,"** is described in a leaflet recently issued by The Walterisation Co. Ltd., Purley Way, Croydon, Surrey.

Amongst the most widely-used of the pre-treatment processes to improve the corrosion resistance and adhesion of paint applied to materials subject to outdoor exposure is the thin film of phosphate afforded by the accelerated so-called " paint-bonding " treatments.

These provide a micro-crystalline coating which forms a protective insulating layer on the surface of the metal. The phosphate coating has excellent holding properties for films of paint, and the composite coating of phosphate and paint has a considerably better corrosion resistance than that provided by the paint alone. Other advantages afforded by the presence of the phosphate coating include resistance to the spread of corrosion at the inter-face in the event of piercing or rupture of the paint film by mechanical damage, and adhesion of the paint film throughout slight deformation of the steel base.

The " Fasbond " series of treatments is amongst the most effective of the phosphating processes. The process produces in a few minutes a highly corrosion resistant coating with excellent paint-bonding properties, sufficiently smooth to take a single-coat finish.

The material can be used by immersion or by spray in manual, semi-automatic or fully automatic plants. The solutions are stable giving ease of operation and economical consumption of chemicals.

The leaflet can be obtained free upon request.

# Latest Developments in PLANT, PROCESSES AND EQUIPMENT

## Pumps for Chemical Liquids

ILLUSTRATED in Fig. 1 is the "Neumo" pump, designed for service in the plating industry and now being distributed by Kingsbourne Products Ltd., 216 South Coast Road, Peacehaven, Sussex.

The pumps are manufactured in a variety of materials such as cast iron, brass, stainless steel and P.T.F.E. The last named is made by Imperial Chemical Industries Ltd., under the trade name "Fluon", and is inert to all the various chemicals employed in the plating industry, so that a pump made in this material is completely versatile.

Stainless steel or P.T.F.E. coated pumps, in which all the surfaces in contact with the pumped liquid are of one of these materials, are the most popular in the range. The pumps are ideally suited to such applications as supplying abrasive media to polishing mops.

The illustration shows a pump made of P.T.F.E. having steel bolts to take the main thrust of the pump. The makers say that the novel construction of the plunger pushrod assembly ensures that a completely unbroken face of P.T.F.E. is presented to the liquid being pumped. The light valve springs are made entirely of this material, and total cost compares favourably with a pump made of stainless steel.

Normal construction of the motor is a solid cast iron valve-block bolted to a solid cast-iron piston block, both blocks having honed bores to accommodate their respective components. The valve is solid and of high grade steel, hardened and ground to fine limits. The piston is of similar material finished in the same way and equipped with Nylon piston rings to obviate air leakage. A specially-designed porting system between the two blocks eliminates any tendency towards stalling, often present in systems that employ air pressure delivered alternately to each end of a cylinder. If weight is an important consideration in design, the motor can be manufactured of light alloys with suitable liners.

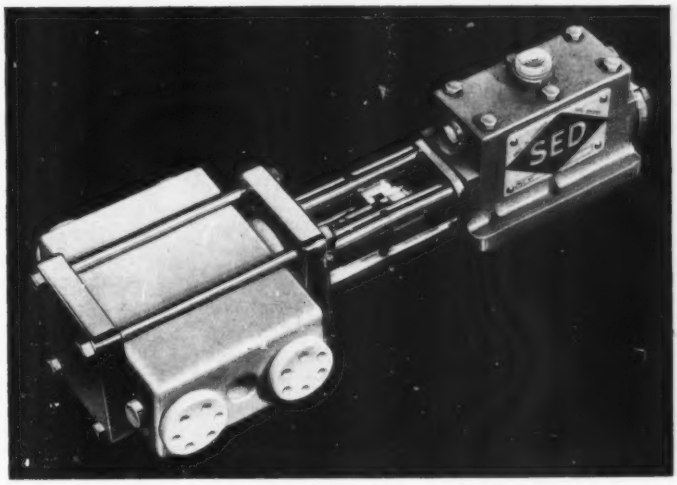



*Fig. 1—A pump, made of material inert to most chemicals used in the plating trades, is especially interesting to metal finishers.*

In operation, the energy imparted to the piston of the motor is transferred to the pump's plunger by connecting rods having gland packings of different materials according to the liquid to be pumped. The distance between pump and motor is approximately 4 in. and circular mounting flanges at both motor and pump are separated by four steel tie rods forming a protective cage for the connecting rods and preventing any rotation of the motor piston.

Air consumption is between 2½ and 3½ cu. ft. per min. at 65 to 80 lb. per sq. in. depending upon circumstances. Maximum delivery of thin viscosity liquid is 200 gall per hr. with no head. By adjustment of relative bore sizes between motor and pump a considerable range of deliveries as against pressures can be obtained. The unit can be safely operated in flame proof areas.

## Humidity Test Cabinets

THE introduction of three larger models of their well-established series HTC humidity test cabinets, was announced recently by Barlow-Whitney Ltd., 2, Dorset Square, London, N.W.1.

The new units are catalogued under references HTC 5, 6 and 7. Respective internal dimensions

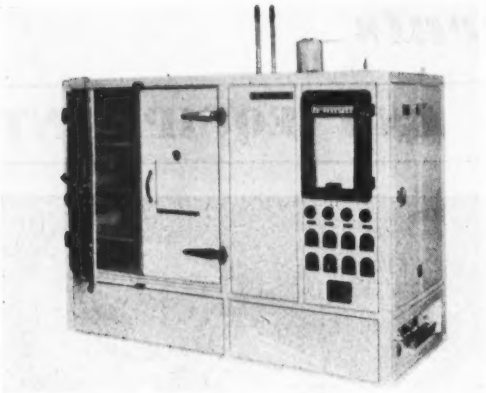


*Fig. 2—Larger versions of the H.T.C. series of self-contained humidity test cabinets*

are : (5) 36-in. cube (6) 54-in. wide x 36-in. high x 36-in deep (7) 72-in. wide x 36-in. high. x 36-in. deep, and are designed to meet the demand for cabinets of increased capacity for subjecting intermediate and larger electrical, electronic and telecommunication components and assemblies, samples of packaging, plating and protective finishes and many other materials, to the exacting humidity tests specified by the appropriate sections of such official specifications as K114 (Issue 2), RCS11 (Issue 5) etc. Like the smaller HTC 2 and 3 models they incorporate accurate and flexible control of both temperature and humidity, so that they are also valuable for general laboratory service.

The cabinets are entirely self-contained units, only requiring connection to electrical and water services, and provision for drainage. The interiors are constructed from heavy tinned copper and have excellent thermal and corrosion resisting characteristics. The humidifier is arranged for easy inspection, and particular attention has been paid to the air circulator so that uniform distribution of temperature and humidity prevails under all conditions.

The control system comprises adjustable electric thermometers, relays and input regulators catering for dry heat temperatures from ambient to 100°C. Relative humidity conditions from 40 per cent to 99 per cent can be produced with temperatures to 70°C. Provision is also made for controlled cyclic temperature variation under damp heat conditions adjustable for both amplitude and frequency.

Other features include large viewing windows and interior inspection lighting and conveniently located holes for test leads that can be sealed by rubber inserts when not in use. Strong wire mesh or special trays are supplied to requirements.

Optional features include a time switch, a 2-pen recorder (as in Fig. 2 above) and an ultra-violet irradiation device. The cabinets are also available with refrigerator equipment for operating down to approximately 0°C. if required.

The introduction of a new and extensive range of small-and medium-sized standard, general-purpose electrically-heated industrial trayloading ovens, with alternative types to cover all industrial applications such as baking, curing, drying, polymerising, stoving, etc., was also announced recently by this company. (Fig. 3)

Series E.150 ovens are of all-steel double-skin construction, the cavity walls and door being fitted with nonsag pads to minimize heat loss. The heating elements are housed in the base or side walls behind anti-radiation shields. Close temperature regulation can be made by an adjustable hydraulic thermostat with separate neon indicator. In this series, the ovens are arranged with natural ventilation, but can be supplied with a motor-driven fan as an optional extra. Work-trays are of wire mesh or expanded metal.

The Series E.300 ovens, although available with natural ventilation, are usually fitted with full forced circulation having either horizontal or vertical air flow. This is achieved by a motor-driven fan in the roof of the oven. An electrical interlock ensures that the heaters are only in circuit when the fan is running. Temperature is controlled by a dial indicator-regulator, and a safety thermostat is fitted to limit the temperature, protecting both the charge and the heating elements should the main controller fail.

*Fig. 3.—The series E.150 standard electric oven*

Recorders and other instruments can be provided to suit any specific requirements.

Optional extras include the incorporation of explosion reliefs if the ovens are required for processes involving explosive hazards. A ventilation arrangement can also be included to prevent the escape of toxic fumes from the oven.

### Direct Reading Instrument

AN American firm, the Delsen Corporation, 719 West Broadway, Glendale 4, C., U.S.A., has developed a portable, non-destructive, direct reading instrument, for laboratory or factory, to measure the dissipation factor and dielectric constant of insulating materials.

The instrument, the "D-K Analyzer," can be used to investigate the effects of variables such as hardeners, fillers, and cure conditions in dielectric systems, to detect non-uniformities in the electrical properties of insulators caused by variable resin content or inadequate cure, and to inspect incoming material such as etched circuit board stock to ensure conformity to standards. In addition, it lends itself to monitoring the output of continuously operating devices, such as coating machines, to permit rapid process readjustments, to examine large finished systems, such as radomes for uniform electrical properties, or to analyse materials with similar appearance to facilitate stock separation.

The instrument's probe eliminates the need for specimen preparation. Measurements can be quickly made, the results being indicated on two dials. No calculations are required, and access to a system need only be from one side. Several hundred measurements can be made in an hour.

The analyser is available as a battery operated unit for "floor" use, or as a laboratory instrument with a plug-in power supply. In either form, it measures 9 in. by 12 in. by 9 in. and weighs less than 15 lb.

### Polythene Storage Bin

A STORAGE bin, T.B.250, moulded in natural colour polythene (semi-transparent white) has been added to the range of bench assembly trays and storage bins marketed by Kabi Precision Components (Barnet) Ltd., 13 Byng Road, Barnet, Herts.

Primarily designed for the handling and storage of materials and components in the engineering and allied industries, the T.B.250 containers in the new material can also be used for the handling and storage of meat products and as wet ice containers in aircraft pantries.

The bins have a combination of toughness, chemical inertness, flexibility at low temperatures and resistance to water and water vapours that makes them particularly valuable for many uses in industry.

## Classified Advertisements

*Prepaid rates:* FIFTEEN WORDS for 7s. 6d. (minimum charge) and 4d. per word thereafter, or 24s. per inch. Box number 2s. 6d., including postage of replies.

### SITUATIONS VACANT

**METAL FINISHING-ENGINEERING MANAGER** required for two factories. Must have a bent for simplicity and efficiency. Dohm Ltd., 167, Victoria St., London, S.W.1.

**ESTIMATING ENGINEER** required for internal sales department of firm manufacturing automatic metal finishing plant in Outer London Area. O.N.C. and experience with welded tanks and structures desirable. The Company is located in a new factory in pleasant surroundings ; lunch vouchers, Sports and Social Club ; pension scheme. Box. No. 203.

### MACHINERY FOR SALE

**PLATING AND ANODISING M.G. SETS**

250 amp., 5 volt G.E.C.
500 amp., 6 volt Canning.
240 amp., 60 volt E.C.C.
500 amp., 24 volt L.S.E.
600 amp., 30 volt Mather & Platt.
750 amp., 60 volt Mather & Platt.
500 amp., 60 volt Crom. Park.
750 amp., 20 volt. Canning.
1,250 amp., 55 volt G.E.C.
1,500 amp., 10 volt Canning.
1,600 amp., 12 volt Mather & Platt.
2,000 amp., 4.5 volt Morley.
2,000 amp., 6.5 volt Morley.
1,250 amp., 60 volt G.E.C.

RECTIFIERS

500 amp., 6 volt Canning.
1,000 amp., 8 volt Canning.

BRITANNIA MANUFACTURING CO., LTD.,
Britannia Walk, London, N.1
Clerkenwell 5512/4.

### MACHINERY WANTED

WANTED one second hand gas fired camel back oven, overall length approximately 30′ x 7′ 6″ wide complete with conveyor and drive gear. Operating temperature 300° to 350°F. Two 8ft. wide water wash spray booths complete with centre partitions, extract fans and water pump, details to ;—Grundy Equipment Limited, High Street, Cowley, Middlesex.

PRESS TOOLS
MOULDS
GAUGES
DIES

NEED
HARD CHROME
PROTECTION
AGAINST WEAR

Toolroom maintenance costs are always high — electro-deposited HARD CHROME may be a solution to your problem.

We manufacture equipment, large and small capacities, which will produce Hard Chrome surfaces on various types of tools to ensure accuracy and long life.

Let us help you to keep your tools in production instead of lying idle in the toolroom.

Consultations, layout of plant and technical advice on large or small installations form part of the Cruickshank service available to prospective customers, free of charge.

*Illustration by kind permission of Pilkington Bros. Ltd., St. Helens, Lancs.*

CRUICKSHANKS

**R. CRUICKSHANK LTD**
CAMDEN STREET · BIRMINGHAM
S.M.C2809

Phone: CENtral 8553 (6 lines)
Grams: Cruickshank, Birmingham

# SPACE

## FOR GROWING INDUSTRI

Is your factory old, inconvenient, too small, its lease running out?

Are you short of workers, and are those you have badly housed, tired of long journeys and loss of time whenever there is a traffic hold-up?

## HAVERHILL or THETFORD

SUFFOLK NORFOLK

## OFFER YOU

- SITES for FACTORIES with all services
- NEW HOUSES for your workers
- LABOUR available through a selective recruitment scheme

## WHAT ARE YOUR DIFFICULTIES?

Disposing of your existing premises? Lack of sufficient capital for new building?

## PERHAPS WE CAN HELP OR ADVISE YOU!

*The London County Council in co-operation with these towns has set up an Industrial Centre at the County Hall, S.E.1, to deal with London industrialists. Write (ref. VA/G/8) or telephone for more information or an appointment—WATerloo 5000, Extension 7494 and 7595.*

y, 195

USTRI

t, too

those
long
there

FORD

services

elective

S?

k of suf-